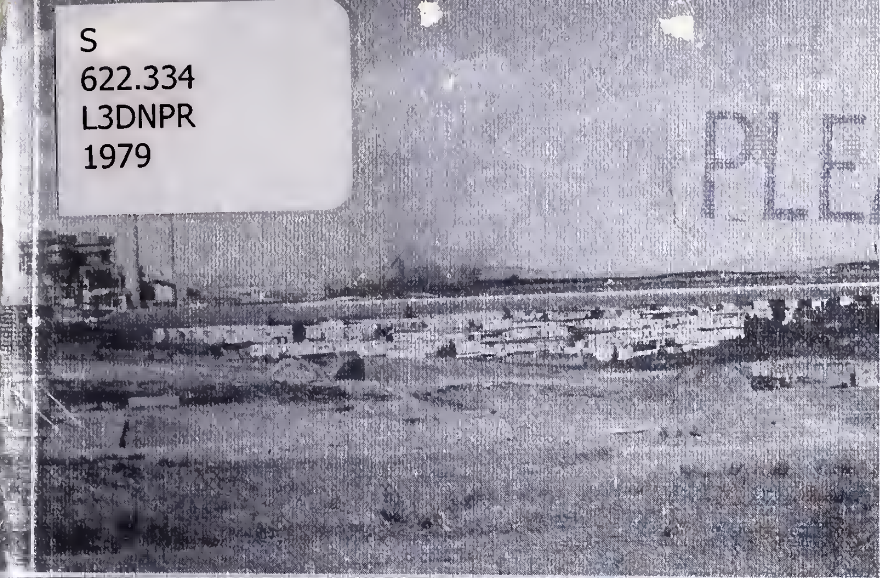
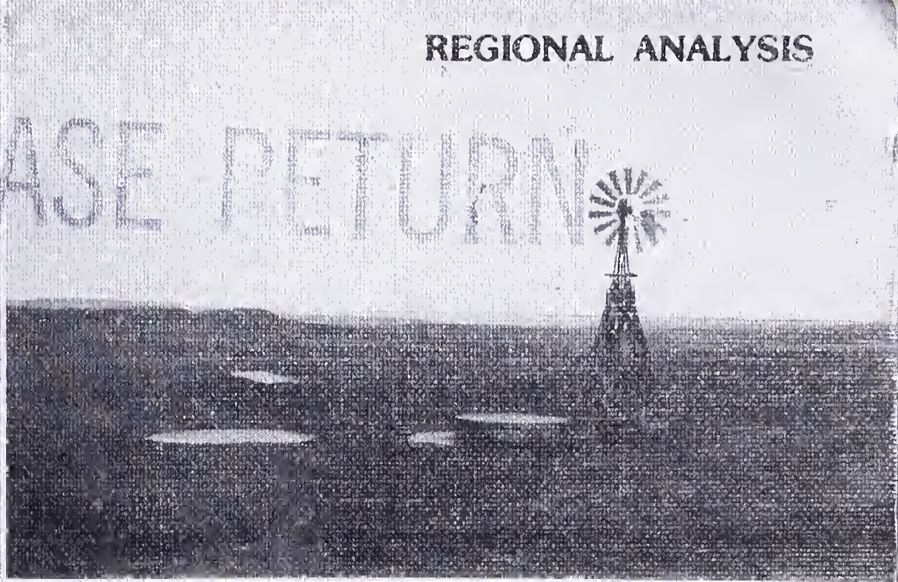
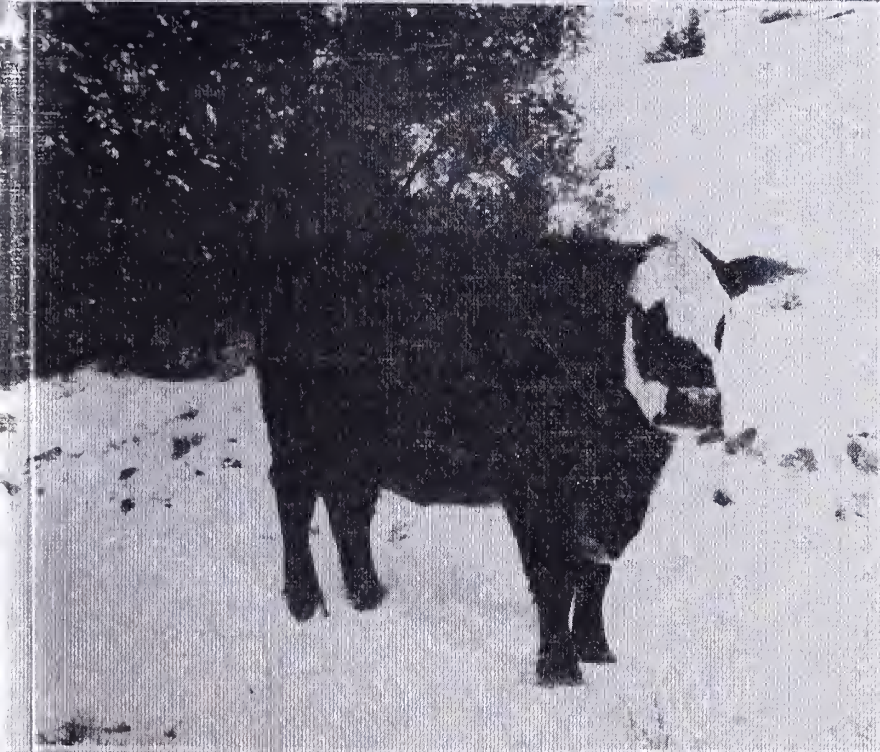
REGIONAL ANALYSIS

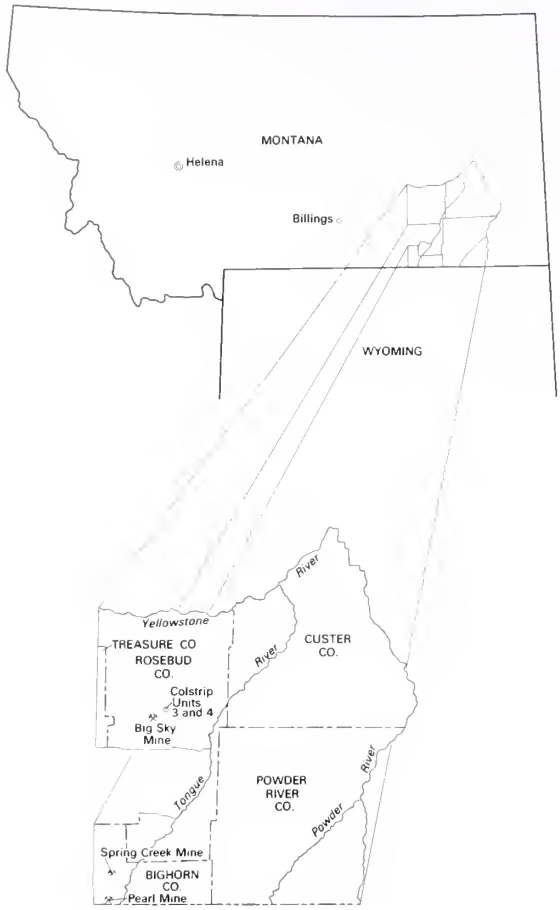






DRAFT ENVIRONMENTAL STATEMENT

NORTHERN POWDER RIVER BASIN COAL, MONTANA



ENGLISH-METRIC CONVERSION FACTORS

To convert English unit	Multiply by	To obtain Metric unit
Inches (in)	2.54	Centimeters (cm).
Feet (ft)	3.048×10^{1}	Centimeters (cm).
	3.048×10^{-1}	Meters (m).
Miles (mi)	1.609	Kilometers (km).
Square feet (ft^2)	9.290×10^{-2}	Square meters (m^2).
Acres	4.047×10^{-1}	Hectares (ha).
	4.047×10^{-3}	Square kilometers (km^2).
Acre-feet (acre-ft)	1.233×10^{3}	Cubic meters (m^3).
	1.233×10^{-3}	Cubic hectometers (hm^3).
Cubic yards (yd^3)	7.646×10^{-1}	Cubic meters (m^3).
Pounds (lb)	4.536×10^{-1}	Kilograms (kg).
Short tons (tons)	9.072×10^{-1}	Metric tons (t).
Pounds per acre (lb/acre)	1.12	Kilograms per hectare (kg/ha).
Btu/lb	2.326	Kilojoules per kilogram (kJ/kg).
Gallons (gal)	3.785×10^{-3}	Cubic meters (m^3).
Gallons per minute (gal/min)	6.309×10^{-2}	Liters per second (L/s).
Degrees Fahrenheit (°F)	([1])	Degrees Celsius (°C).

[1]Temperature in °C =(temperature in °F - 32)/1.8.

U. S. DEPARTMENT OF THE INTERIOR

MONTANA DEPARTMENT OF STATE LANDS

DRAFT

ENVIRONMENTAL STATEMENT

REGIONAL ANALYSIS

NORTHERN POWDER RIVER BASIN COAL, MONTANA

Prepared by

U. S. Geological Survey, Department of the Interior

Montana Department of State Lands

Leo Berry, Jr., Commissioner
Montana Department of State Lands

H. William Menard, Director
U. S. Geological Survey

1979

SUMMARY

(X) Draft ( ) Final Environmental Statement

Department of the Interior, U.S. Geological Survey

Montana Department of State Lands

1. Type of action: (X) Administrative ( ) Legislative

2. Brief description of action. In compliance with the National Environmental Policy Act of 1969, this statement is an analysis of environmental impacts from current coal development proposals on existing leases in the northern Powder River basin of Montana. Three mining and reclamation plans ("mine plans") have been proposed for Federal and State approval; two electric power-generating units have been proposed for Federal approval.

The mine plans include 3,828 acres of existing Federal coal leases and 540 acres of private coal leases. A total of 7,400 acres of Federal and private land would be required for the mines, related facilities, and rights-of-way.

Volume I of this statement analyzes cumulative impacts of the proposed developments, considered in the context of other existing and projected coal-related development in the area. Three levels of coal production are analyzed: low, intermediate (most probable), and high levels. Volume II is a site-specific analysis of the proposed Pearl mine. Site-specific analyses of the proposed Spring Creek and Big Sky mines have been released as FES 79-10 and DES 78-51 respectively. The proposed generating units have been analyzed in DES 79-2.

3. Summary of Environmental Impacts

- Impacts on air quality would be significant, in that the National Ambient Air Quality Standards for total suspended particulates would frequently be exceeded near all three minesites during mine life. Degradation of air quality would cause subtle injury to vegetation within about 1 mile of the mines and about 4 miles of the generating units, slightly reducing vegetative productivity.

- Wildlife populations, primarily antelope, mule deer, and sage grouse, would be significantly reduced during mine life and probably for several decades after mining. Antelope would be affected the most: as many as 300 would be lost in the Decker area during the first severe winter. The uses of wildlife for hunting and viewing in the Decker area would be reduced for decades.

- Social impacts would be significant in Colstrip and Forsyth--comparable to those experienced during the construction of Colstrip units 1 and 2. The proposed developments would introduce about 6,000 people to the six-county study area (20 percent of the total influx by 1990); they would contribute accordingly to the continuation of

social impacts that began in the last decade. The total population of the study area would increase from about 60,000 at present to about 82,000 by 1990. At least during the 2 or 3 years of most rapid growth, local governments, formal and informal institutions, and social networks in Colstrip and Forsyth would not be able to meet the demands placed on them.

- Population growth associated with the construction of Colstrip units 3 and 4 would create temporary fiscal problems in the town of Forsyth and the school districts in Forsyth and Colstrip; the impact would not be significant, partly because these towns have experience in dealing with growth-related problems. The increase of 1,800 jobs (8 percent of the anticipated total of 23,000 by 1990) would continue the trend of increasing employment in the study area.

- Regional population increases, due in part to the proposals, would stress recreation facilities in Forsyth, Colstrip, Sheridan, and at the Tongue River Reservoir. Facilities would likely be upgraded, so the impact would not be significant.

- Because the proposed mines would account for one-sixth of the projected coal train traffic leaving the region by 1990, impacts on transportation are not expected to be significant. The potential for train-vehicle accidents would increase commensurately with the increase in train traffic. In addition, noise, dust, and diesel emissions from coal trains would noticeably increase along the rail corridors leading east from the region.

- Disturbance to soils, topography, and vegetation would not be significant from a regional perspective. On about 3,000 acres at the proposed mines, however, soils disturbance would slightly decrease potential vegetative productivity and correspondingly limit long-term land use for livestock grazing and wildlife use. Erosion would mostly be limited to the minesites during mining, and would increase negligibly off the minesites following reclamation, under proper management.

- The temporary reduction in grazing land by mining would not be significant: the land uses temporarily displaced by mining are abundantly available on other lands throughout the study area. About 3,000 acres would be disturbed by the proposed developments by 1990, causing a loss of about 8,700 animal unit months (AUM's) of forage production through 1990. Existing and concurrent mining would disturb 20,000 additional acres by 1990, with a corresponding loss in AUM's.

- Impacts on water flow and quality would not be significant: demand for water (about 40,000 acre-feet/year by 1990) would probably nowhere exceed available supply, nor would water quality anywhere be degraded enough to interfere with anticipated uses.

- Some unknown number of archeological artifacts would not be identified before mining and the opportunity to study them would be lost. This

loss would not be significant because representative sites would already have been studied.

- The local degradation of esthetic quality near the mines would not be significant, because the minesites are not now esthetically distinctive.

4. Alternatives Considered:

- Administrative alternatives available to the Secretary of the Interior.
- Administrative alternatives available to State agencies.
- Technological alternatives available to Federal and State authorities.

5. Comments on the draft environmental statement have been requested from various agencies, State clearing houses, and the public. See summary attachment 1 and chapter IX.

6. Date draft environmental statement was made available to EPA and the public:

SUMMARY ATTACHMENT I

Comments are being solicited from the following agencies and organizations.

Federal agencies

Advisory Council on Historic Preservation
Bonneville Power Administration
Federal Energy Regulatory Commission
Interstate Commerce Commission
U.S. Department of Agriculture:
  Forest Service
  Soil Conservation Service
U.S. Department of the Army; Corps of Engineers
U.S. Department of Energy
U.S. Department of Health, Education, and Welfare
U.S. Department of Housing and Urban Development
U.S. Department of the Interior:
  Bureau of Indian Affairs
  Bureau of Mines
  Bureau of Reclamation
  Fish and Wildlife Service
  Heritage Conservation and Recreation Service
  National Park Service
  Office of Surface Mining
U.S. Department of Labor:
  Mine Safety and Health Administration
U.S. Department of Transportation
U.S. Environmental Protection Agency

State and local agencies

Big Horn County Commissioners
Custer County Commissioners
Employment Security Commission of Wyoming
Montana Bureau of Mines and Geology
Montana Department of Agriculture; Pesticide Division
Montana Department of Community Affairs
Montana Department of Fish and Game
Montana Department of Environmental Sciences:
  Air Quality Bureau
  Food and Consumer Safety Bureau
Montana Department of Natural Resources
Montana Energy Advisory Council
Montana Environmental Quality Council
Montana Historical Society
Office of the Governor of Montana
Office of the Governor of Wyoming
Powder River County Commissioners
Rosebud County Planning Director
Sheridan Area Planning Agency
Sheridan County Commissioners
Sheridan County Planning Commission
Treasure County Commissioners

State and local agencies--continued

Wyoming Department of Administration
Wyoming Department of Revenue and Taxation
Wyoming State Highway Department

Other organizations

ACTION for Eastern Montana
ASARCO Incorporated
Burlington Northern Railroad
City of Gillette
Cumin Associates
Decker Coal Company
Dist. VII Human Resource Council
Milwaukee Railroad
Montana Power Company
Montana State University
MONTCO
Mountain Bell Telephone Company
Northern Cheyenne Research Project
Northern Energy Resources Co., Inc.
Northern Plains Resource Council
Old West Regional Commission
Pacific Power and Light Company
Peabody Coal Company
Powder River Basin Resource Council
Range Telephone Cooperative
Shell Oil Company
Sheridan Chamber of Commerce
Sheridan-Johnson Rural Electric Association
Sierra Club
Tongue River Electric Cooperative
Tri-County Ranchers Association
University of Montana
University of Wyoming
VTN, Inc.
Western Energy Company
Westmoreland Resources, Inc.
Yellowstone-Tongue Areawide Planning Organization

CONTENTS

ILLUSTRATIONS

TABLES

CHAPTER I

DESCRIPTION OF THE PROPOSALS UNDER CONSIDERATION

A. BACKGROUND

The Secretary of the U.S. Department of the Interior is considering for approval proposals for two new surface coal mines, one surface mine expansion, and two coal-fired power-generating units (considered as one proposal) in the northern Powder River basin of Montana. The Commissioner of the Montana Department of State Lands is also considering for approval the proposed new mines and mine expansion. The purpose of this environmental impact statement (EIS) is to provide an overview of the cumulative impacts of the four proposed developments, considering their relation to other existing or projected coal-related developments.

1. Scope

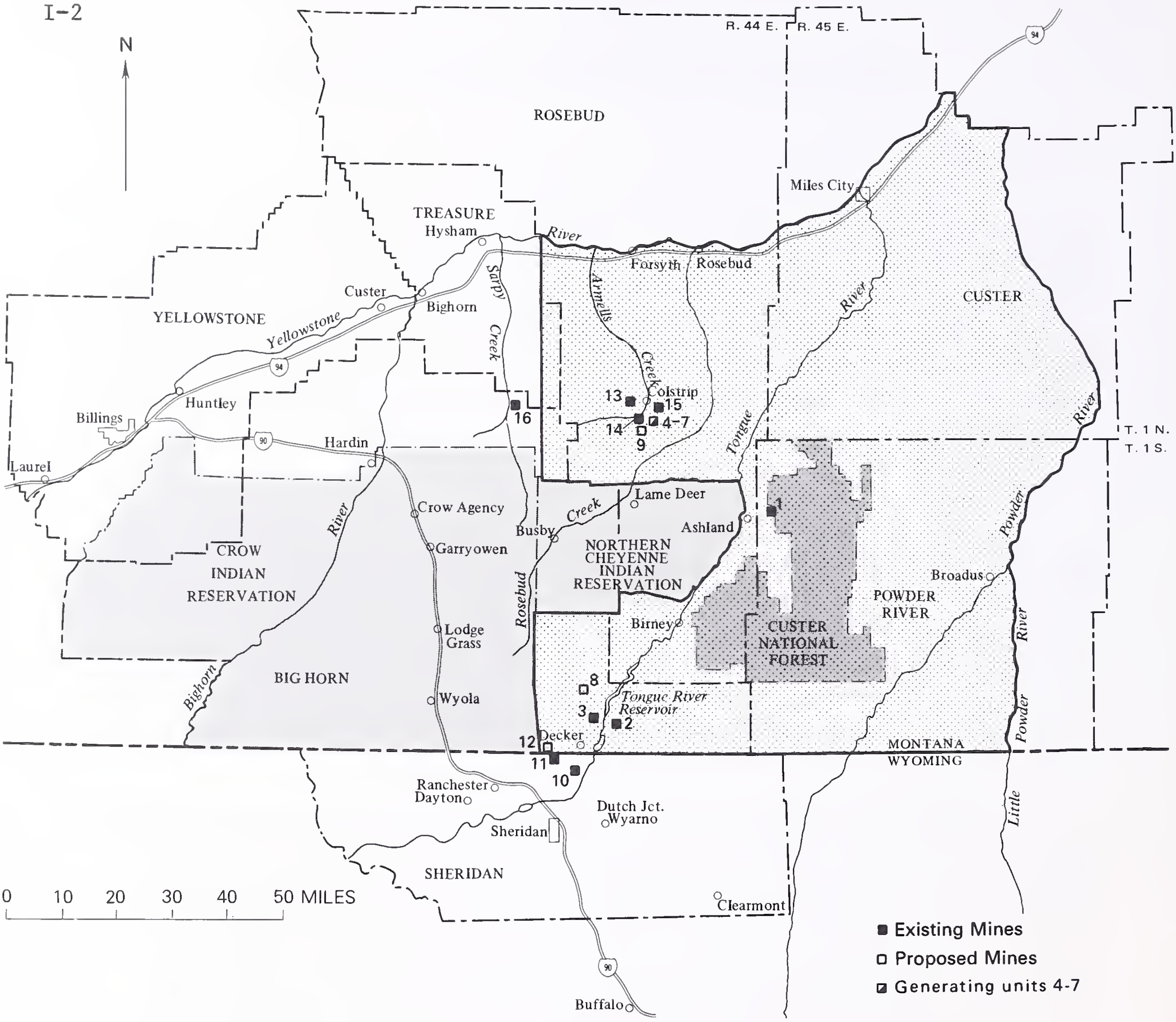
The four proposed developments are the only mining and reclamation plans (hereinafter termed mine plans) and related coal-conversion facilities currently proposed for Federal and/or State approval in a 7,500-square-mile region within the northern Powder River coal basin in southeastern Montana. (See inside front cover and fig. I-1.) This region was designated for study in an EIS by the Secretary of the Interior in April 1976. About 10 percent of the designated region is in the Ashland Division of the Custer National Forest, which is excluded from mining under the Surface Mining Control and Reclamation Act of 1976.

The designated region excludes the Crow and Northern Cheyenne Indian Reservations because Indian coal is under the jurisdiction of the individual tribes and the Bureau of Indian Affairs. Consideration of any proposed coal developments located on the reservations is thus beyond the scope of this EIS. The EIS does, however, consider any impacts the proposed developments would have on the reservations. Similarly, it considers other impacts resulting from implementation of the proposals that would extend beyond the designated region, mainly impacts on air quality, community services, the economy, society, and transportation. In these disciplines the "study area" extends beyond the boundary of the designated region to the extent the impacts are significant.

Current coal production in the designated region is about 26 million tons/year (mty). Another 7 mty is now being mined in areas adjacent to the designated region, including northern Sheridan County, Wyo., and on coal owned by the Crow Indian tribe. If the proposed mines are developed, they would produce about 13 mty by 1990. Total coal production from existing, proposed, and projected mines in the designated region would be about 53 mty by 1990. An additional 35 mty would be produced by 1990 from existing and projected mines in areas adjacent to the designated region. Table I-1 and figure I-2 show current and projected production.

2. Timeframe of Analysis

Because of the uncertainties in anticipating long-term energy demand, this EIS attempts to analyze foreseeable coal-related developments only



1. Coal Creek[c]
2. Decker--East[c]
3. Decker--West[c]

Montana Power Co.--
generating units

4. #1[c]
5. #2[c]
6. #3[a]
7. #4[a]
8. NERCO--Spring Creek[a&b]
9. Peabody--Big Sky Expansion[a&b]
10. Peter Kiewit--Big Horn[c]
11. Pub. Serv. Okla.--Ash Creek[c]
12. Shell Oil Co.--Pearl[a&b]
13. Western Energy--Rosebud Area A[c]
14. Area B[c]
15. Area E[c]
16. Westmoreland--Absaloka[c]

[a]Federal approval required.
[b]State approval required.

[c]Ongoing sites not requiring Federal or State approval in this EIS.

FIGURE I-1.--Intermediate level of production--location of ongoing and proposed mines and generating units. Projected additional mines are not shown.

TABLE I-1.--Coal production in the study area (1978-90)

[Millions of tons/year]

	1978	1980	1985	1990
Designated region				
Existing mines (Western Energy--Rosebud Areas A, B, and E; Decker--East and West; Peabody--Big Sky; Coal Creek)	25.5	31.3	23.0	18.2
Proposed mines (NERCO--Spring Creek; Shell--Pearl; Peabody--Big Sky expansion)	0	6.0	13.2	13.2
Projected additional development (Western Energy--Rosebud Areas C and D; Decker--North Extension)	0	2.0	13.5	21.8
Subtotal	25.5	39.3	49.7	53.2
Adjacent Areas				
Existing mines (Peter Kiewit--Big Horn; Westmoreland--Absaloka; Public Service of Oklahoma--Ash Creek)	7.4	10.0	12.5	13.8
Projected additional development	0	2.0	21.0	21.0
Subtotal	7.4	12.0	33.5	34.8
Total	32.9	51.3	83.2	88.0

through 1990. The proposals under consideration would still be active well after 1990--probably until about 2005 under current mine life projections. The EIS considers their impacts after 1990 to the extent possible. Table I-2 shows the anticipated life of the proposed mines; they may continue operation beyond the life shown if they receive permits to mine different areas on their existing leases.

3. Preparation

Approval of the proposals under consideration requires preparation of EIS's under the provisions of the National Environmental Policy Act and the Montana Environmental Policy Act. Preparation of this EIS was begun in 1976 by the U.S. Geological Survey (USGS), Bureau of Land Manage-

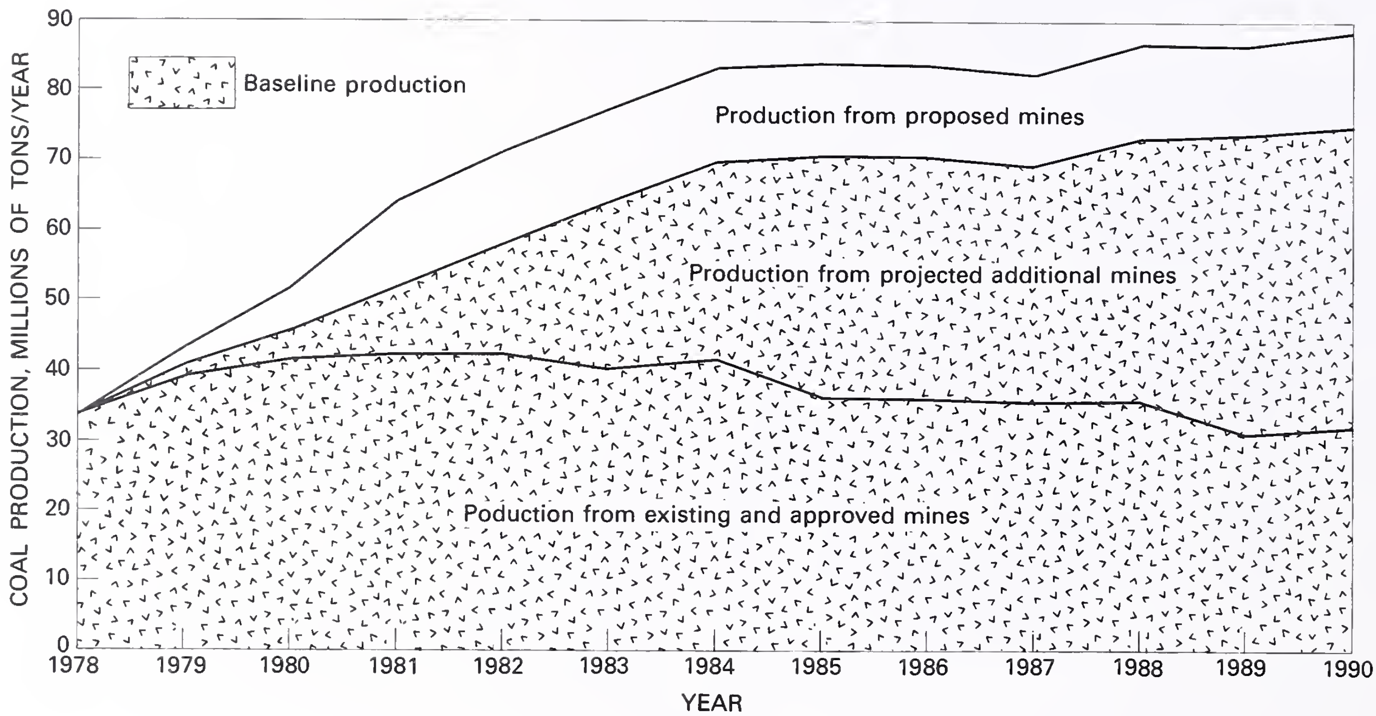


FIGURE I-2.--Intermediate level of coal production from existing, projected, and proposed mines. Baseline includes coal production from mines within and adjacent to the designated region.

ment (BLM), and State of Montana, under USGS and State of Montana leadership. Other Federal participants were the Bonneville Power Administration, Bureau of Mines, Fish and Wildlife Service, and Forest Service. State participants were the Montana Department of State Lands and the Lieutenant Governor's Office.

4. Future Environmental Reviews

This EIS does not propose new coal leasing, nor does it commit the Secretary of the Interior to a new coal leasing program or to the issuance of new coal leases. The following Government actions may require additional environmental review under the National Environmental Policy Act (NEPA) or the Montana Environmental Policy Act (MEPA):

- Issuance of Federal coal leases under current short-term criteria.

- Approval of future mining and reclamation plans not covered in this EIS, including new plans on existing leases and modification of existing operations.

- Approval of applications for rights-of-way for ancillary facilities, including roads, railroad spurs, powerlines, telephone lines, pipelines, and conveyor systems to be constructed on Federal or State lands outside the immediate area of mining operations.

- Reevaluation of mining plans at least every 5 years for renewal in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the Montana Strip and Underground Mine Reclamation Act.

- Exchange or replacement of unleased Federal coal for leased Federal coal in areas of high environmental concern, pursuant to the Federal Coal Leasing Amendments Act.

TABLE I-2.--Proposed coal mines in the designated region

	Peabody Coal Co. Big Sky	NERCO Spring Creek	Shell Oil Co. Pearl
Permit application area (acres)--	1,264	3,074	1,462
Federal coal lease area (acres) (total)------------------------	4,307[1]	2,347	541
Private coal lease area (acres)--	540	0	0
State coal lease area (acres)----	0	0	0
Start construction---------------	N/A	1979	1979
Full production------------------	1981	1982	1982
Full production rate (mty)-------	4.2	7.0	2.0
Permanent employees--------------	114	253	136
Mine life (years)----------------	7[2]	25	20
Total area to be mined (acres)---	894	1,400	541
Average annual acreage mined-----	112	56	27
Unit trains/week (incl. returning empties)-----------------------	16	27	8
Market area----------------------	Minnesota	Texas	Texas

[1]This is the entire Federal lease M-15965. About 720 acres of the total Federal lease is included in the current permit application.

[2]Production could continue from a different area within the existing lease.

B. PROPOSED DEVELOPMENTS

Three mining companies have proposed two new mines and an expansion of an existing mine in the northern Powder River basin of Montana. All would be surface coal mines. The Pearl and Spring Creek mines would use only Federal coal; the Big Sky mine expansion would use Federal and private

coal (table I-2). In addition, a consortium of several utilities have proposed two 700-megawatt coal-fired power generating units at Colstrip, Montana. These units are addressed in DES 79-2, prepared by the Bonneville Power Administration, and are considered as Federal proposals in this document. After the analysis in this EIS was completed, the companies proposed a new scrubbing process which would reduce emissions from the units. (See chapter IV.)

Peabody Coal Company proposes to expand its existing 2.3 million tons per year (mty) Big Sky mine, 5 miles south of Colstrip, into a new area within the existing Federal lease. Mining in the new area would reach 4.2 mty in 1981 and would employ 114 permanent workers, an increase of 32 over the present number. Peabody's current Federal approval of mining operations has expired, and further coal production is proposed for the new area starting in 1979. (See DES 78-51.)

Northern Energy Resources Company (NERCO), a subsidiary of Pacific Power and Light, proposes a new mine at Spring Creek, about 8 miles northwest of Decker, Montana. Spring Creek Coal Company, a subsidiary of NERCO, would operate the mine. The Spring Creek mine would begin production in 1980 at 3.0 mty following the first year of a 2-year construction period. Full production of 7 mty would be reached in 1982, employing 253 permanent workers. Approval for the Spring Creek mine was granted by the Secretary of the Interior and the Commissioner of State Lands in April 1979; after the analysis in this EIS was completed. (See FES 79-10.)

Shell Oil Company's proposed Pearl mine would be between Youngs Creek and Little Youngs Creek about 6 miles west of Decker. The mine would begin operation in 1981 after a 2-year construction period, and would reach full production of 2.0 mty, employing 136 workers, by 1982. (See Vol. II of this document.)

The three mine permit applications include 946 acres of public land and 5,370 acres of private land. Approximately 252 million tons of coal would be recovered. Table I-2 shows production, employment, and lease information for the proposed mines.

The proposed mine plans analyzed individually in site-specific EIS's and in this regional EIS were submitted for review before the initial regulations required under Section 502 of the SMCRA were issued. Consequently, the proposed mine plans may not comply with these initial regulations (Title 30, Part 700 of the Code of Federal Regulations, hereinafter termed 30 CFR 700). The mine plans have been returned to the companies with a request that they be revised to meet the regulations. As soon as the revised plans are returned to the Montana Department of State Lands (DSL) and the Office of Surface Mining (OSM) they will be evaluated by the appropriate State and Federal agencies to determine if they comply with the regulations under 30 CFR 700 and 30 CFR 211. The mine plans will not be approved until they conform to all requirements. State and Federal laws which regulate the mining and conversion of coal are discussed in chapter III.

C. REGIONAL COAL DEVELOPMENT

This regional EIS considers the effects of the proposed developments superposed on the effects of other coal-related development in the study area. Low, intermediate, and high levels of coal production are estimated, giving three contexts in which the proposed mines and generating units are considered. The intermediate level of development is believed most probable and is the basis for the discussion of impacts in chapter IV. The low and high levels of coal production and their resulting impacts are described and evaluated in chapter VIII. The projected low level of coal production would probably result if the Secretary of Interior approved no new mines on any Federal coal leases, including the proposals considered in this EIS. The projected high level of coal production shows the greatest amount of coal-related industrialization that could reasonably be expected in the area between now and 1990. Figure I-3 compares coal production under the low, intermediate, and high levels of development.

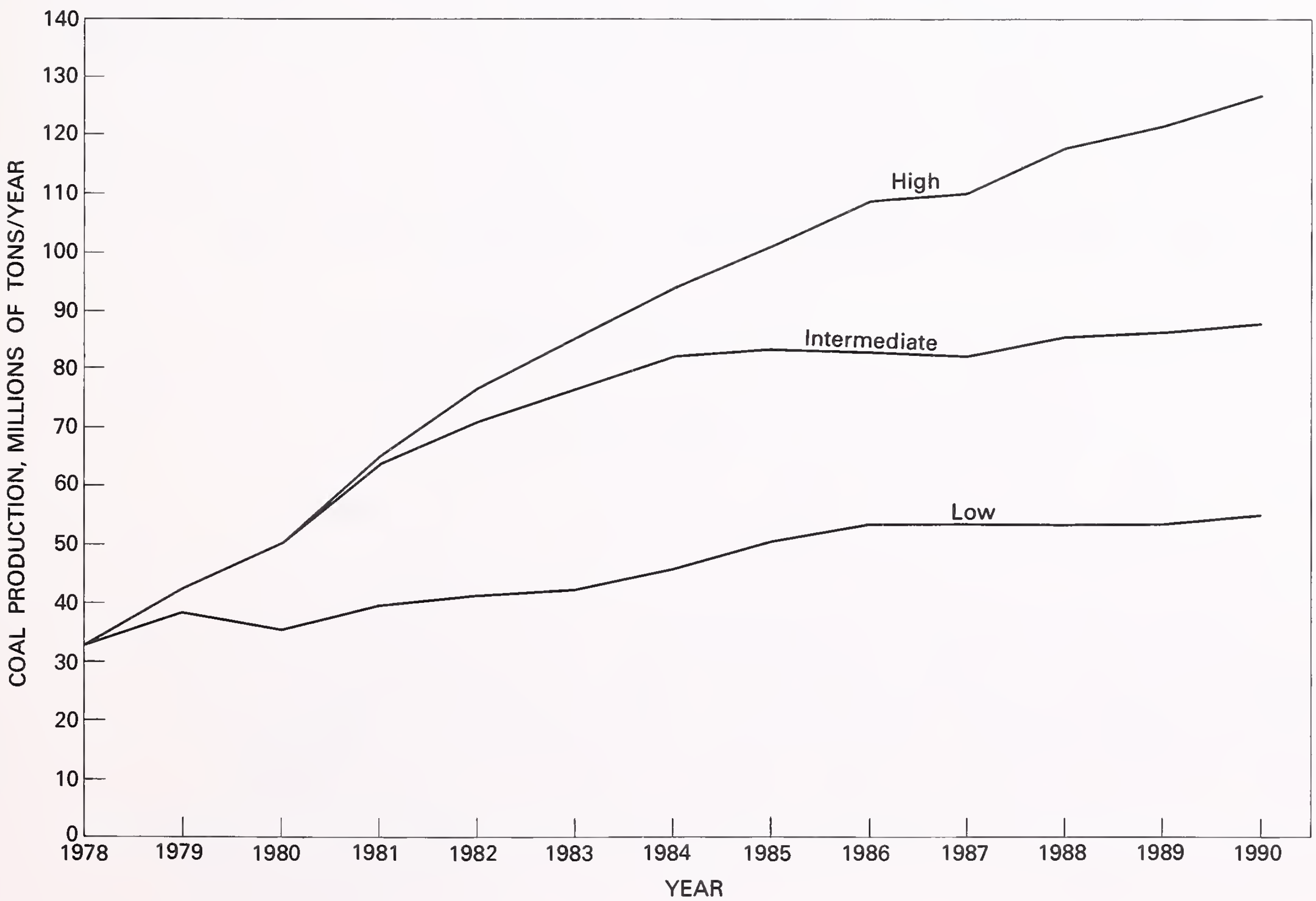


FIGURE I-3.--Projected coal production in the northern Powder River basin study area (designated region and adjacent areas): low, intermediate, and high levels of production.

All existing and proposed coal-related developments within the designated region are localized in two areas, or "subregions"--one surrounding Colstrip and the other surrounding Decker. Moreover, future coal developments projected under all levels of production would be located in or strongly influenced by one or the other of these subregions. The Colstrip and Decker subregions are considered in the broader context of the study area throughout this EIS.

1. Intermediate Level of Coal-Related Development

The intermediate level of development includes the four proposals under consideration, existing coal mines and power-generating units, and assumed development of new mines on existing Federal and private leases. Table I-1 summarizes regional projections.

Existing mines in the study area are expected to produce about 41 million tons per year (mty) in 1980, decreasing to 32 mty by 1990. Those mines within the designated region (in Montana) include:

- Western Energy Company's Rosebud mine, Areas A, B, and E at Colstrip in Rosebud County.

- Peabody Coal Company's Big Sky mine 5 miles south of Colstrip.

- Decker Coal Company's West and East Decker mines, in Big Horn County.

- The Coal Creek mine, 8 miles northeast of Ashland in Powder River County.

Existing mines adjacent to the designated region include:

- Westmoreland Resources' Absaloka mine, at Sarpy Creek Tract III, about 25 miles west of Colstrip on the Crow Ceded area.

- Peter Kiewit Sons' Big Horn mine, in Sheridan County, Wyoming.

- Public Service of Oklahoma's Ash Creek mine, in Sheridan County.

A number of new mines are projected to begin production in the study area by 1990. Most of these projected mines would be adjacent to the designated region, and would add to the impacts expected from the existing and proposed mines. On the basis of their financial commitments, mining companies are expected to apply for permits for the projected mines in the near future. Permit applications for the projected mines have not been received, however, and are not being considered for approval in this EIS. Inclusion of the projected mines in no way implies their eventual approval.

The projected mines would together produce 4 mty in 1980, 45 mty in 1985, and 43 mty in 1990. Those mines include three new mines within

the designated region: Western Energy Company's Areas C and D, which are expected to provide coal for Colstrip units 3 and 4; and Decker Coal Company's North Extension mine, for which a permit application has been made and a joint Federal-State EIS issued (FES 77-20). Table I-1 summarizes coal production from the projected coal mines. The figures are current estimates based on preliminary data which will probably be different when and if the projected mines are eventually approved.

The new town of Spring Creek in southern Big Horn County north of Decker is included as a projected development. The town has an anticipated population of 3,000 by 1990. This EIS does not analyze the town in detail but, instead, considers it in relation to other mining developments in the area.

Other projected developments in the designated region are included in the low and high levels of coal production and are discussed in chapter VIII. Of these, the MONTCO Nance mine is in the process of developing a formal application to the State of Montana for a mining and reclamation permit on private and State coal. A non site-specific analysis of this mine is included in chapter VIII, with emphasis on the mine's regional implications as they relate to other developments.

CHAPTER II

DESCRIPTION OF THE EXISTING ENVIRONMENT

This chapter has two parts. The first part describes the environment at present or in the very near future--about the time that action would be taken on the proposed coal mines and generating units. The second part considers future trends not including the current proposals.

In each discipline, the discussion focuses on the the area that would be impacted by the three proposed mines and two proposed generating units. The detail and extent of discussion is different for each discipline: impacts on soils, for example, would be largely confined to the minesites, whereas impacts on air quality and social conditions would be more far-reaching. For this reason, the description of soils in this chapter is mostly limited to the proposed minesites, while the description of current air quality or social conditions considers a broader area extending beyond the boundary of the designated EIS region (fig. I-1). In effect, each discipline has its own "study area" which may be larger or smaller than the designated region. An attempt is made to show how these study areas fit into a broader context.

A. GEOLOGY

The structural Powder River basin is a broad north-trending synclinal downwarp approximately 250 miles long and 100 miles wide in eastern Wyoming and southeastern Montana. In various parts of the basin, including southeastern Montana, coal beds are exposed at the surface or are close enough to the surface to be economically strip mined. This EIS focuses primarily on the Montana portion of the Powder River basin.

1. Topography and Geomorphology

a. Topography

The northern Powder River coal basin is part of the Great Plains physiographic province (Fenemann, 1931). The area is drained by northward-flowing tributaries of the Yellowstone River (fig. II-1).

All major streams and rivers in the area flow in alluvial valleys that are typically floored by flood plains and bordered by steep valley walls or remnants of alluvial terraces. The valley floors and adjacent terraces are generally composed of unconsolidated alluvial sediments.

The land surface typically is a rolling upland dissected by steep-walled valleys. In some places badlands have formed in easily eroded shales. Locally rugged ridges, mesas, and buttes are capped by resistant sandstone or clinker. Hilltops are commonly 100 to 500 feet higher than adjacent valley floors. Maximum elevations are 4,400 to over 4,800 feet in the Wolf and Little Wolf Mountains in the western part of the area, in the Badger Hills near the Montana-Wyoming border, and on several peaks along major drainage divides. Minimum elevations along

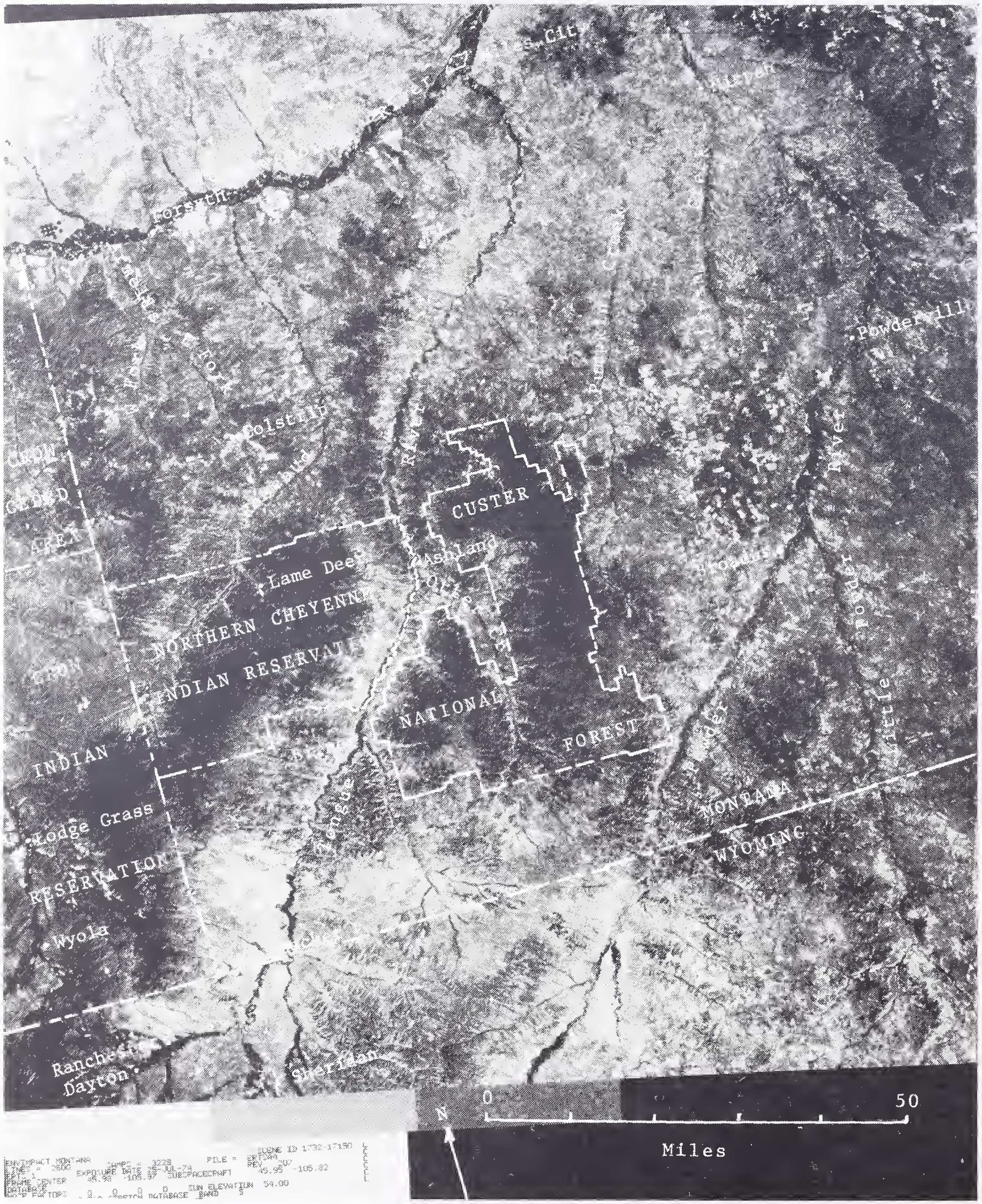


FIGURE II-1.--Picture image of the northern Powder River basin transmitted from a height of 570 miles by Earth Resources Technology Satellite (now known as LANDSAT), July 25, 1974. Dark tones are produced by vegetation; light tones are produced by exposed soil or sparse vegetation.

the Powder and Tongue Rivers are about 3,500 feet at the Montana-Wyoming line and 2,200 feet at the confluence of the Powder and Yellowstone Rivers.

Geologic mapping (Lewis and Roberts, 1978[1]) in the northern Powder River Basin shows recent alluvial deposits along the larger streams (figs. II-2 and II-3). These deposits and other deposits on smaller streams presumably meet the geomorphic criterion for the definition of alluvial valley floors under the Surface Mining Control and Reclamation Act; however, they do not necessarily meet the hydrologic and land-use criteria found in that Act. (See chapter III.) The formal determination and designation of alluvial valley floors has not been made generally in the region. Such determinations may have been made or may be made on a site-specific basis; see, for example, FES 79-10 on the proposed Spring Creek mine.

b. Geomorphic processes (erosion and sedimentation)

Although there are no data on erosion rates in the region, annual source-area sediment yields range from zero to 1.2 acre-feet per square mile along Otter Creek and from zero on bottomlands to 2.1 acre-feet per square mile on steep slopes along Bear Creek, a headwater tributary of Otter Creek (U.S. Dept. of the Interior, 1975, 1976). Sediment yields provide estimates of the lower limit for erosion rates. Estimates based on data from the upper Cheyenne River basin in southwestern South Dakota and east-central Wyoming (Hadley and Schumm, 1961), where precipitation and geology are similar to the northern Powder River basin, indicate that annual sediment yields from the Fort Union Formation average 1.3 acre-feet per square mile and range from zero to more than 30 acre-feet per square mile in small steep watersheds. Sheet erosion supplies most of the sediment yield because it affects the most area. Gully erosion is dramatic but affects less area.

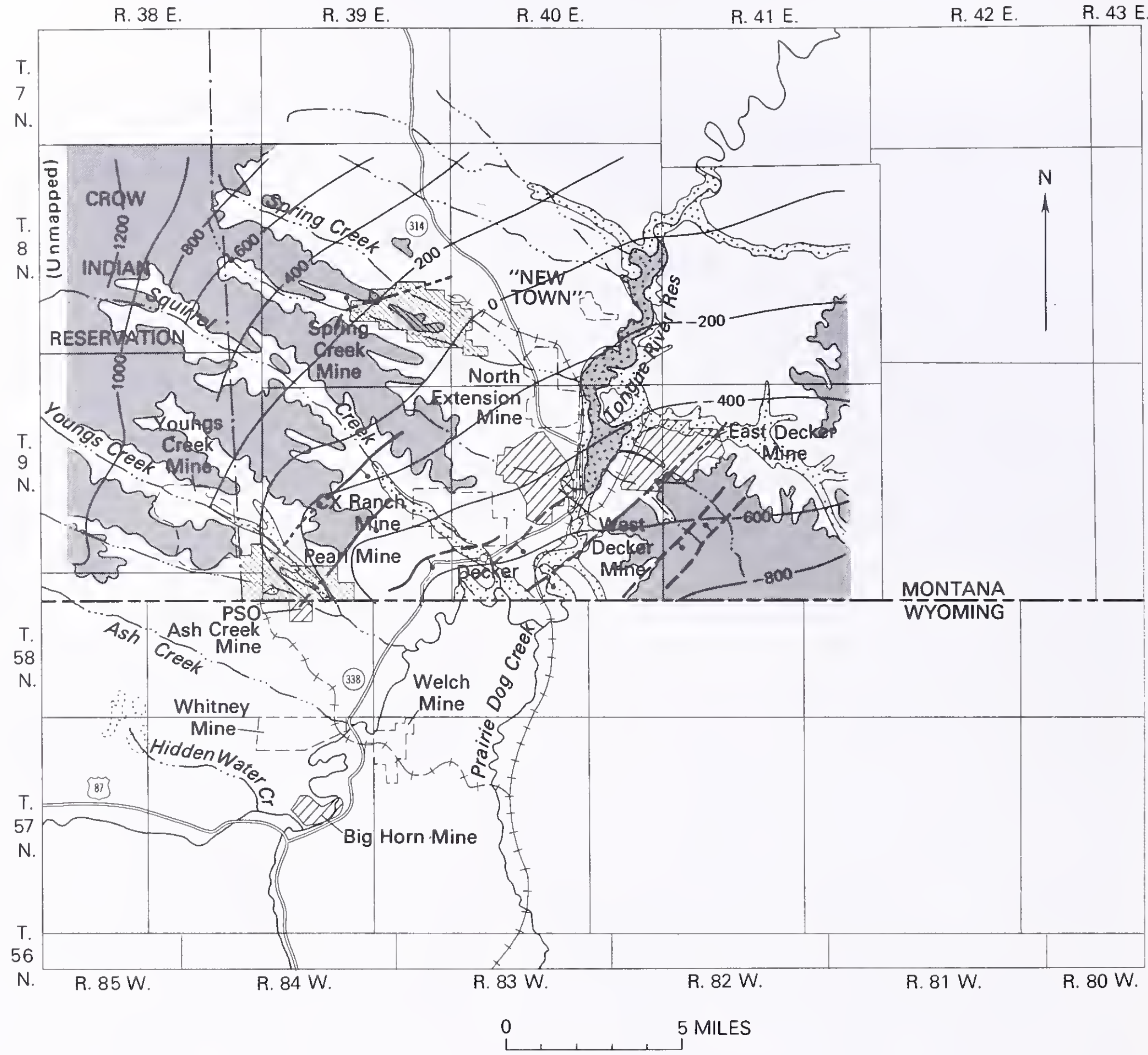
It has not been determined whether most ephemeral stream channels in the area are aggrading or gullying. The reports on Otter Creek and Bear Creek, cited above, both indicate that stream channels within both their study areas are aggrading. Parts of Emile Coulee just east of the present Big Sky mine may also to be aggrading, but parts of South Fork Spring Creek are gullied.

2. Stratigraphy

Rocks exposed in the northern Powder River basin are mostly of the Fort Union Formation of Paleocene age. The overlying Wasatch Formation of Eocene age is exposed in the southern part of Big Horn County and southwestern Powder River County, and the underlying Late Cretaceous Hell Creek Formation is exposed in the eastern and northwestern parts of

---

[1]This map is available on request from the U.S. Geological Survey, Environmental Impact Analysis Program, P.O. Box 25046, Mail Stop 701, Federal Center, Denver, CO 80225.



Existing mines

Proposed mines

Other projected mines (baseline and low levels)

Orphan spoils

Proposed railroad spur

Existing railroad spur

Alluvium (Holocene age)—Sand, silt, clay, and local lenses of gravel. Deposits are as much as 75 feet thick along the Tongue River, and 40 feet thick along smaller streams. Map unit includes terraces adjacent to streams.

Wasatch Formation (Eocene Age)—Lenticular beds of sandstone and interbedded shale and coal. Base of unit is mapped at the top of the Roland coal bed, at the top of the Fort Union Formation.

Fort Union Formation (Paleocene age) Tongue River Member—Calcareous sandstone and siltstone. Commonly contains light-buff to light-gray shaly siltstone and brown to black carbonaceous shale. Contains numerous coal beds.

Fault—Long dashed where approximately located; short dashed where inferred. Bar and ball on downthrown side.

—200— Structure contour—Shows altitude of top of the Bearpaw Shale which is Upper Cretaceous in age. Datum is mean sea level.
In the Decker area, the top of the Bearpaw Shale is approximately 4,000 below the base of the Wasatch Formation and the top of the Fort Union Formation. In the Colstrip area, the top of the Bearpaw Shale is approximately 1,200 feet below the base of the Tongue River Member of the Fort Union Formation.

FIGURE II-2.--Geology of the Decker subregion. Source: Lewis and Roberts, 1978.

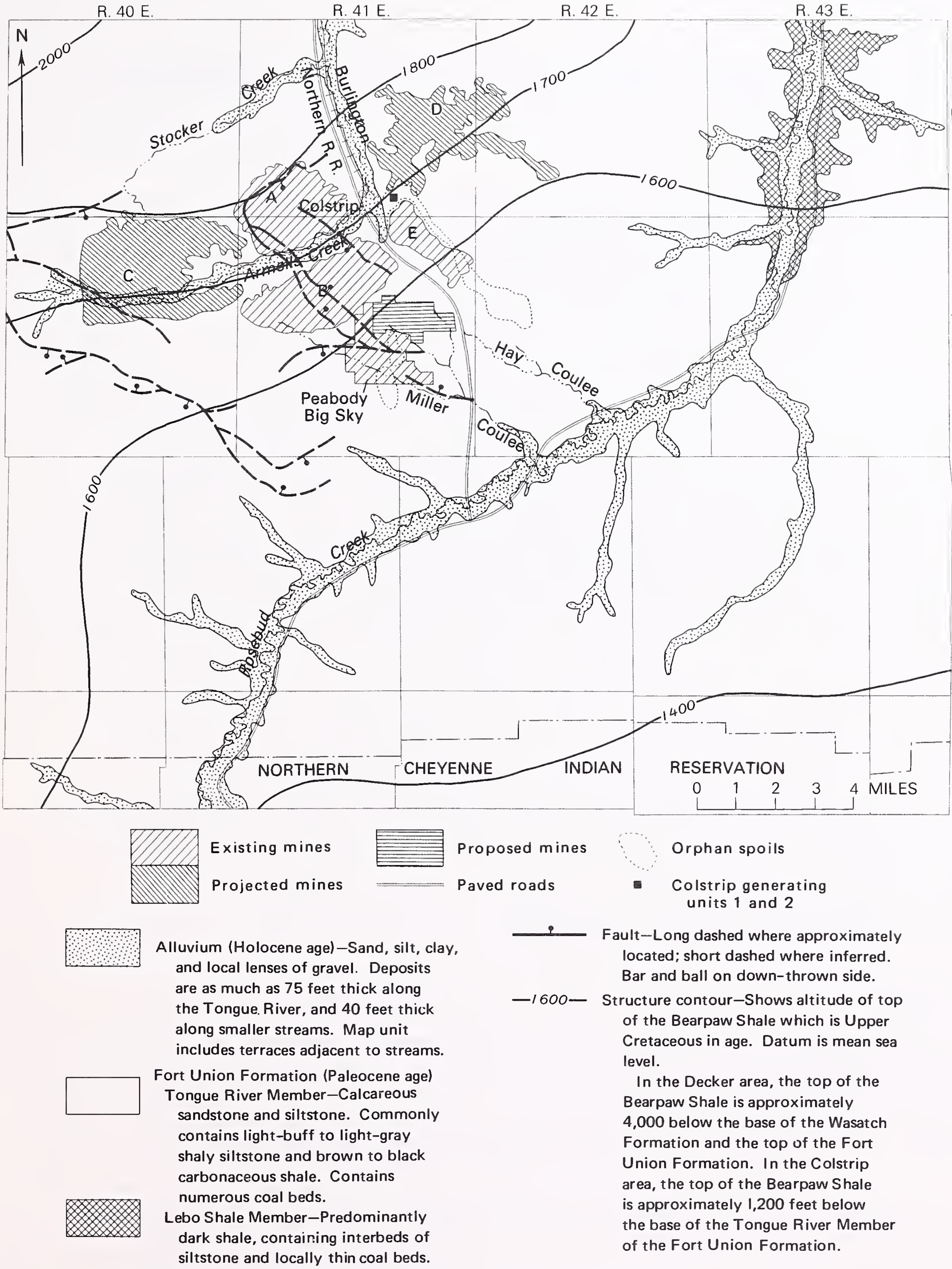


FIGURE II-3.--Geology of the Colstrip subregion. Source: Lewis and Roberts, 1978.

the basin. Surficial deposits of alluvium and stream gravel occur along the main stream valleys. Lewis and Roberts (1978) briefly described these units.

3. Structure

The Powder River Basin in Montana is a broad south-plunging synclinal fold. Many low-amplitude subsidiary folds are superimposed on the main fold. Faults with displacements of a few feet to 200 feet offset the upper part of the Fort Union Formation and the basal part of the Wasatch Formation at places in the basin.

4. Geochemistry of Overburden

The most available geochemical data are bulk chemical analyses, which indicate total concentrations of elements in overburden. These data show upper limits to the concentrations potentially available, following reclamation, to vegetation (as nutrients or toxic elements), or available to degrade the ground water. Studies of the bulk chemistry of the Fort Union Formation (Ebens and McNeal, 1977; Hinkley and Ebens, 1977; Hinkley and others, 1978) suggest that the overburden geochemistry varies negligibly across a typical minesite but that it varies considerably with depth, reflecting differences among rock strata within the Fort Union Formation. No bulk chemical data are available for the Wasatch Formation, which overlies the Fort Union Formation at the Spring Creek and Pearl minesites.

In general, the geochemical diversity of the overburden is much greater than that of the surface soil. Mapel and others (1976) reported that maximum concentrations of certain potentially harmful elements (fluorine, mercury, thorium, calcium, lithium, and sodium) are greater in the overburden than in the soil. Ebens and McNeal (1977) reported that the concentration of other potentially harmful elements (boron, chromium, copper, fluorine, gallium, molybdenum, and nickel) are higher in shale than in either soil or sandstone. If taken up by plants, these elements could be harmful to the plants themselves or to animals that would feed on those plants. (See chapter IV, Vegetation.)

Mineralogical data for the region are limited (Hinkley and others, 1978; Hinkley and Ebens, 1976). These data provide information important for assessing impacts on ground water. Sandstones, although dominated by quartz, contain large amounts of feldspars and various clay minerals. Total clay content of fine grained rocks is fairly constant throughout the region, but the composition of the clays varies regionally (Hinkley and Ebens, 1976). Both gypsum and pyrite have been reported in overburden at mines throughout the region (Rahn, 1976).

Overburden containing clay minerals that swell when wetted tends to produce mine spoils that become relatively impermeable, thereby impeding the normal downward movement of moisture from the surface. At the Big Sky minesite, Arnold and Dollhopf (1977) reported moderate amounts of clay

minerals that have a relatively low potential for swelling when wetted (illite, kaolinite and minor amounts of chlorite). In contrast, the Decker mine, has a predominance of clays with a relatively high potential for swelling when wetted (smectite with varying amounts of illite, and very little chlorite and kaolinite).[2]

Another type of geochemical data is required by the State as part of any application for a mining permit. These data are used in determining the suitability of overburden as a reclamation medium, and include pH (a measure of acidity or alkalinity), electrical conductivity (EC; related to the concentration of soluble salts), and sodium-adsorption-ratio (SAR; a measure of potential adverse effects on the physical properties of soil), as well as plant-available levels of nutrients and trace metals. Compared with bulk geochemical and mineralogical data, which vary vertically with changes in rock types, the suitability data are more variable; they vary both vertically and laterally across minesites and regionally.

Measurements of pH, EC, SAR, and trace metals within overburden are compared with State "suspect levels" (table III-5). Throughout the region, molybdenum in the Fort Union overburden exceeds the suspect levels. SAR values vary widely; in the southern part of the region, they frequently exceed State suspect levels. Other values locally exceed State suspect levels. For the proposed mines, these analyses are as follows:

- Spring Creek.--Most of the overburden exceeds State suspect levels for SAR, molybdenum, nickel, and cadmium. Individual strata exceed suspect levels for pH, conductivity (salinity), nitrate, and manganese.

- Big Sky.--Much of the overburden exceeds State suspect levels for conductivity (salinity), cadmium, molybdenum, and nickel. Some strata exceed suspect levels for pH, SAR, boron, copper, lead, zinc, and nitrate.

- Pearl.--Most of the overburden exceeds State suspect levels for cadmium, molybdenum, and nickel. Part of the overburden exceeds suspect levels for nitrates, conductivity, SAR, and zinc.

Several overburden characteristics could produce revegetation problems. (See chapter IV, Soils.) Throughout the region, soluble-extract levels of magnesium exceed those of calcium, and molybdenum concentrations almost uniformly exceed State suspect levels. Locally, the overburden contains strata in which pyrite (a sulfide), conductivity (salinity), sodium, or trace-metal concentrations could inhibit revegetation. Mining would break up undesirable layers but would not greatly dilute the concentrations of undesirable components. Recent studies at Colstrip (Dollhopf and others, 1978) indicate that when problematic layers composed less than 5 percent

---

[2]M. Klages, Peter Kiewit Mining Company, letter of May 27, 1975.

of the overburden volume, they were diluted and undetectable after mining. If they composed 5 to 15 percent of the overburden volume, they were undetectable after mining half of the time; but, if they composed 15 percent of the overburden volume, they maintained their identity with mining. If pockets of undesirable overburden were placed in the root zone, revegetation would be locally inhibited. Because bulk chemical trace-metal concentrations in the overburden exceed the plant-available concentrations, weathering may, over time, increase plant-available concentrations. Even after a period of weathering, formerly suitable overburden may exceed State suspect levels and may possibly inhibit vegetation.

Analyses of ground water in mine spoils indicate that, at least locally, spoil waters are degraded in quality. However, since the oldest spoils in the region are only 50 years old, such analyses may reflect only short-term geochemical changes. Therefore, the long-term changes in concentration and composition of spoils water are still undetermined. Geochemical prediction of such changes is difficult,[3] mineralogical data are sparse, and data characterizing the geochemical environment of spoils (pH, oxidation or reduction potential, and partial pressures of dissolved gases) are virtually absent. Availability of trace metals, which is important to both water quality and revegetation suitability, is particularly difficult to predict, because trace metals only rarely appear as major constituents of discrete mineral phases.

5. Paleontology

Plant and invertebrate fossils occur in all geologic units mapped in the region. In addition, the remains of crocodilelike reptiles and turtles occur in the Fort Union Formation, and bones and teeth of mammals occur in the Wasatch Formation and the surficial deposits. These fossils do not appear to be significant according to criteria developed by the Bureau of Land Management, namely: (1) they do not provide important information on evolutionary trends among organisms; (2) they do not provide information on the development of biological communities or interactions between botanical and zoological biotas; (3) they do not demonstrate unusual or spectacular circumstances in the history of life; (4) they are not in short supply or in danger of being depleted or destroyed; and (5) they are available in other locations. Fossils in the Spring Creek area (Bown and McGrew, 1976) are poorly preserved or unidentifiable and are better represented in equivalent rocks outside the region. It is possible, however, that important paleontological materials may be exposed during mining, in which case the company would have to proceed with mitigations outlined by the BLM and approved by the USGS.

---

[3]A more complete analysis is found in "Geochemistry of the Fort Union Formation with Implications for Quality of Waters in Mined Lands," by M. J. Woods (1978), unpublished report on file at the Montana Department of State Lands, Capitol Station, Helena, MT 59601.

6. Geologic Hazards

Geologic hazards in the area are negligible (Algermissen and Perkins, 1977). The probability of damage from earthquakes is low. Landslides and rockfalls are unlikely in open-pit coal mines in the region because the rocks to be disturbed support stable slopes and have low susceptibility to landsliding (Nichols and Chleborad, in Osterwald and others, 1977). Foundation conditions for structures, such as buildings, railroads, and highways, are generally good (Farrow and Osterwald, in Osterwald and others, 1977) except locally over clinker, which is subject to differential settling, or over swelling clays.

Coal fires have been a problem in abandoned underground mines, particularly in northern Sheridan County. Coal fires are a minor problem during strip mining, however, and are highly unlikely following strip mine reclamation because combustible materials are buried.

7. Mineral Resources

a. Coal

Coal occurs in all three members of the Fort Union Formation but principally in the Tongue River Member, which contains several thick persistent beds and many thinner ones. The Wasatch Formation, which overlies the Fort Union Formation, contains one coal bed of possible interest for mining. Correlations of the coal beds across the area are uncertain because the beds merge or split, their thicknesses vary laterally, and the intervals between them vary.

There are about 32 billion tons of potentially strippable coal in the northern Powder River basin. The coal underlies approximately 1,200 square miles (770,000 acres) in beds 9 to 50 feet thick, under less than about 150 feet of overburden. There are about 178 billion tons of coal in the area, in beds as deep as 1,500 feet and as thin as 1.5 feet (Matson and Blumer, 1973; Matson, 1975). Figure II-4 shows the distribution of strippable coal deposits in the region; figure II-5 shows the distribution of Federal and non-Federal minerals ownership in the region.

Coal in the region ranges from lignite A through subbituminous A; its heat value at the powerplant ranges from 6,350 to 9,940 Btu per pound. In general, the coal having higher heat value and lower moisture content occurs in the southwestern part of the region. Also, the most deeply buried coals tend to have the highest rank. On exposure to air, the coal tends to lose moisture, to slake, and to ignite spontaneously.

Most of the coal is low-ash, low-sulfur coal that consistently contains 4 to 8 percent ash and 0.2 to 0.8 percent sulfur (Mapel and others, 1977). The Knobloch bed in the central part of the region locally contains more than 2 billion tons of potentially strippable coal averaging less than 0.2 percent sulfur and 5 percent ash (Matson and Blumer, 1973).

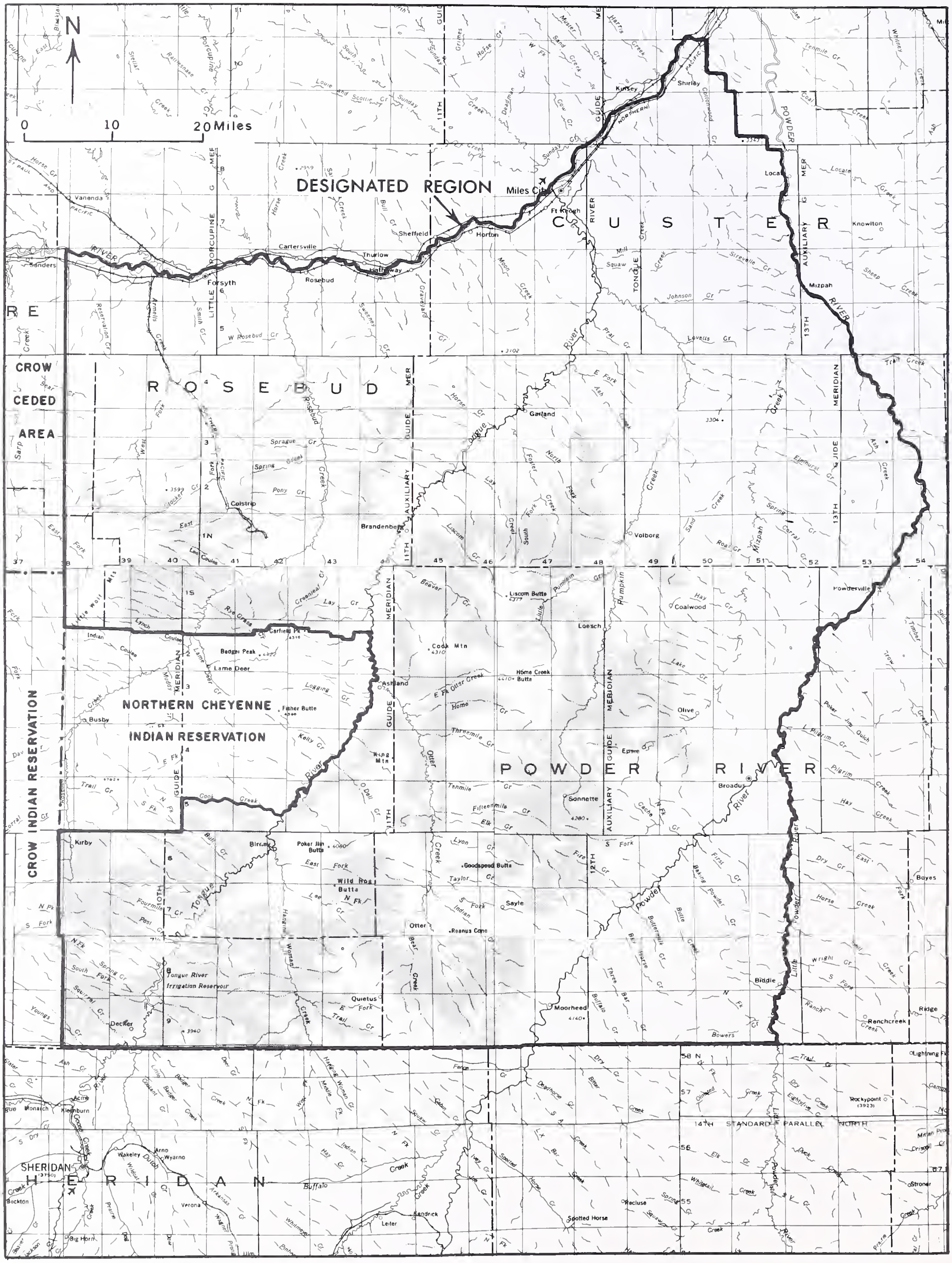


FIGURE II-4.--Distribution of strippable coal deposits in the designated region.

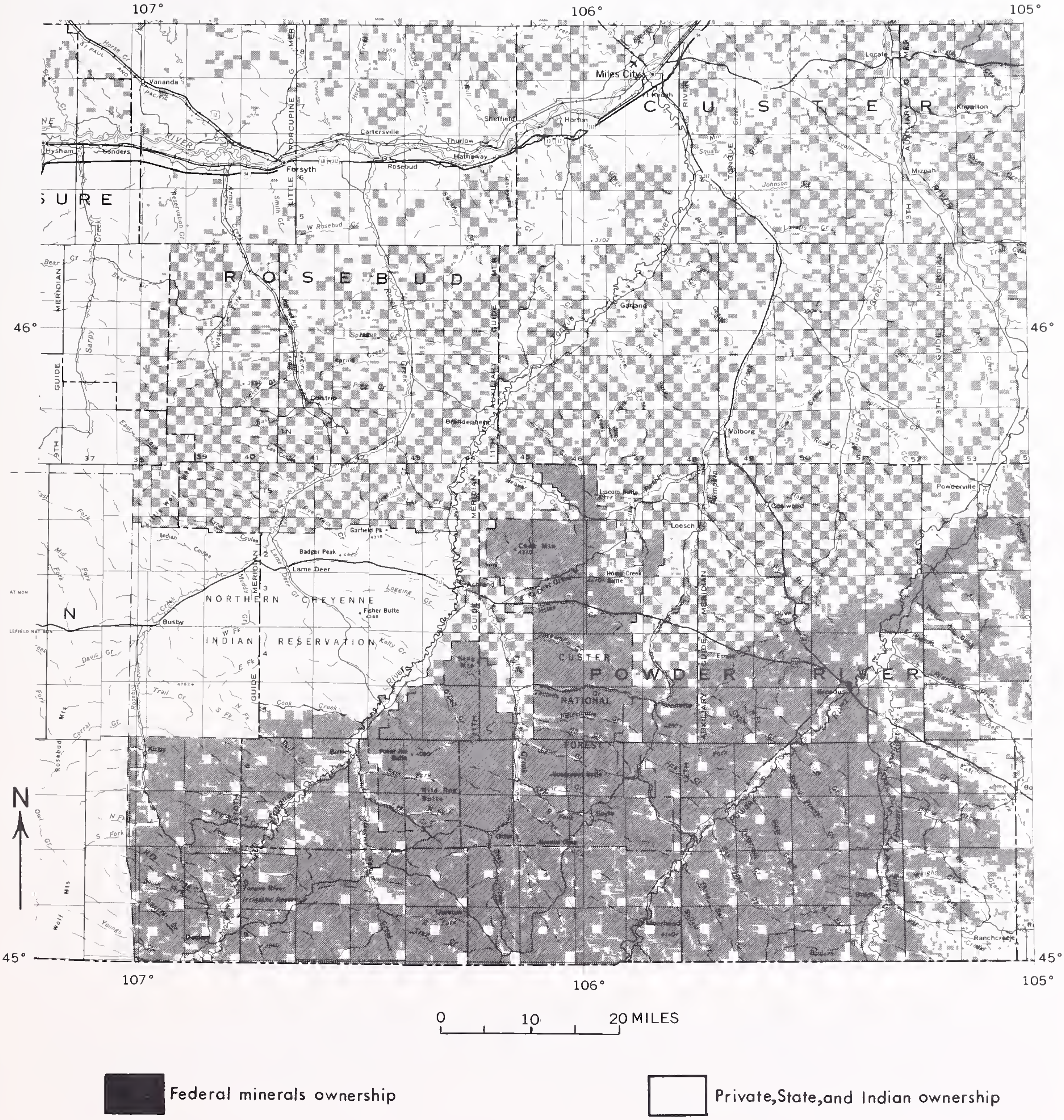


FIGURE II-5.--Distribution of Federal and non-Federal minerals ownership in the designated region. Source: Northern Great Plains Resource Program, 1974.

Complete chemical analyses of the coal from the Colstrip, Ashland, and Decker areas, including analyses for trace elements, have been reported by Mapel and others (1977). In addition, the U.S. Bureau of Mines (1932) and the Montana Bureau of Mines and Geology (Matson and Blumer, 1973) have published several hundred analyses of the coal, including analyses from nearly all of the more than 25 major coal beds in the region. Reports on individual coal fields also contain data on the coal.

In 1976, four large strip mines were producing coal in southeastern Montana for electric power generation (table II-1). In addition, both surface mines and scattered small underground mines and prospects have been intermittently in operation for many years, to supply coal for railroads and local domestic use.

TABLE II-1.--Coal production from operating strip mines in 1978

[Data from the U.S. Bureau of Mines]

Company and mine	Production (short tons)
Decker Coal Co.	8,980,000
Western Energy Co., Rosebud	10,576,000
Westmoreland Resources, Inc., Absaloka	4,554,000
Peabody Coal Co.	2,075,000
Big Horn Coal Co.	2,840,000
Total	29,025,000

b. Oil and gas

Nine oil and gas fields have been discovered in the northern Powder River basin in rocks beneath those that would be disturbed by coal mining. Only the Ash Creek field is near any of the proposed mines: it is a few miles from the Pearl minesite.

Methane gas derived from coal has been produced from shallow wells in the Tongue River Member of the Fort Union Formation in the Wyoming part of the Powder River coal area and used for domestic purposes (Olive, 1957). Three shallow wells had initial productions of 500,000 to 1 million cubic feet per day. Such methane gas may constitute a minor resource in some parts of the northern Powder River coal area, but its potential is unevaluated.

c. Other mineral resources

Lenses of bentonite of fair to poor quality (Magill and others, 1969) occur in the lower part of the Tongue River Member on the Northern

Cheyenne Indian Reservation. The bentonite occurs in beds 6 to 20 feet thick. Similar bentonite deposits probably occur in the northern part of the region, in the Fort Union Formation, beneath the rocks to be disturbed by proposed mining. Commercial resources of bentonite probably do not occur in conjunction with strippable deposits of coal.

Clinker is common in the Tongue River Member. It originated from the baking and fusing of shale and sandstone overlying coal beds that burned in place (Brown and others, 1954). Locally, masses of clinker are more than 100 feet thick. The clinker is widely used for road metal and railroad ballast; its present use is small compared to the large supply available in the region.

Major deposits of sand and gravel occur in stream terraces along the main streams. Some of these deposits have been used locally for road subgrade and road surfacing. Because many of the deposits contain clinker, iron-bearing sandstone fragments, and other rock types, these deposits may not be suitable for making concrete. At places, such as along the Tongue River near Birney, gravels overlie strippable coal deposits.

Most of the clays and shales of the Tongue River Member are unsuitable for manufacturing bricks or other fired products, but about one-third of the shales are suitable for lightweight aggregate (Berg and others, 1970; 1973). Commercial resources probably do not occur in conjunction with strippable coal.

B. HYDROLOGY

Most of the water used in the six-county study area comes from the Yellowstone River and its tributary, the Tongue River. The Tongue River, of most direct concern in this statement, has an average annual unappropriated and unused discharge of 241,100 acre-feet, of which 144,700 acre-feet has been allocated to Montana and 96,400 acre-feet has been allocated to Wyoming. The discharge of these streams is adequate to supply present needs within the study area. Figure IV-1 shows estimated future consumptive uses of water in the study area.

Ground water is available within practical reach of water wells in most of the area in sufficient quantity for domestic stock and light industrial uses. Ongoing mines are the largest users of ground water in the area.

1. Surface Water

The region is drained by tributaries of the Yellowstone River--in downstream order, Armells and Rosebud Creeks, and the Tongue and Powder Rivers. (See figure II-1.) Current mines are on tributaries of Armells and Rosebud Creeks and the Tongue River. The proposed Big Sky expansion and Colstrip generating units are on tributaries of Rosebud Creek.

The Pearl mine is on Youngs and Little Youngs Creeks, which drain into the Tongue River; the Spring Creek mine is on Spring Creek, which drains into the Tongue River Reservoir.

Most of the runoff in the area generally occurs in May and June, owing to snowmelt augmented at times by spring rains. Occasionally, severe rainstorms cause flash flooding and heavy runoff other times of the year.

Streams in the region are typified by the flow of the Tongue River at Miles City (fig. II-6, USGS gaging station 3085). Quantitative estimates of surface-water flow used in this EIS are based on publications of the USGS, principally U.S. Department of the Interior (1977b) and FES 77-20 (Decker mines).

About 36,000 acre-feet of water is released each year from the Tongue River Reservoir to irrigate about 26,000 acres between the reservoir and Miles City. Numerous small dams also divert water for irrigation, but these have little storage potential.

Few useful data are available on the sediment-transport characteristics of the small streams in the study area or of the Tongue River in reaches that might be affected by the proposed developments. Approximations based on runoff records and on sedimentation rates in the Tongue River Reservoir reported by Dendy and Champion (1973) indicate an average sediment concentration (suspended load plus bed load) of about 750 ppm (parts per million). The highest sediment loads, possibly exceeding 5,000 ppm, probably occur in runoff generated by high-intensity summer storms of appreciable areal extent.

The U.S. Department of Agriculture (1974) estimates that sediment yield for the study area averages about 0.5 acre-feet per square mile. (See Geology.) Sediment yields are highly variable and depend on such factors as steepness of terrain, characteristics of surface rocks or soil, volume of runoff, and intensity of precipitation.

The largest users of water are Colstrip generating units 1 and 2, which consume about 13,500 acre-feet annually (Bonneville Power Administration, oral commun., 1977). Montana Power Company has filed for 250 ft^3/s (cubic feet per second) from the Yellowstone River. This filing was made prior to the Yellowstone Moratorium of 1974, which suspended all large applications (diversions of over 20 ft^3/s and storage of over 18,000 acre-feet) for water-use permits in the Yellowstone Basin until March 10, 1977. Presently, Montana Power Company is diverting about 16,900 acre-feet per year (22 ft^3/s) for units 1 and 2. The company may not divert when the flow in the Yellowstone River is less than 1,500 ft^3/s. The lowest mean daily flow for the Yellowstone River at Miles City since operation of Bighorn Lake (Yellowtail Dam) began in 1966 was 2,200 ft^3/s in 1973. The U.S. Bureau of Reclamation (oral commun., 1978) releases minimum flows of 1,000 ft^3/s in the winter and 1,400 ft^3/s during irrigation seasons from Bighorn Lake. These flows, added to normal

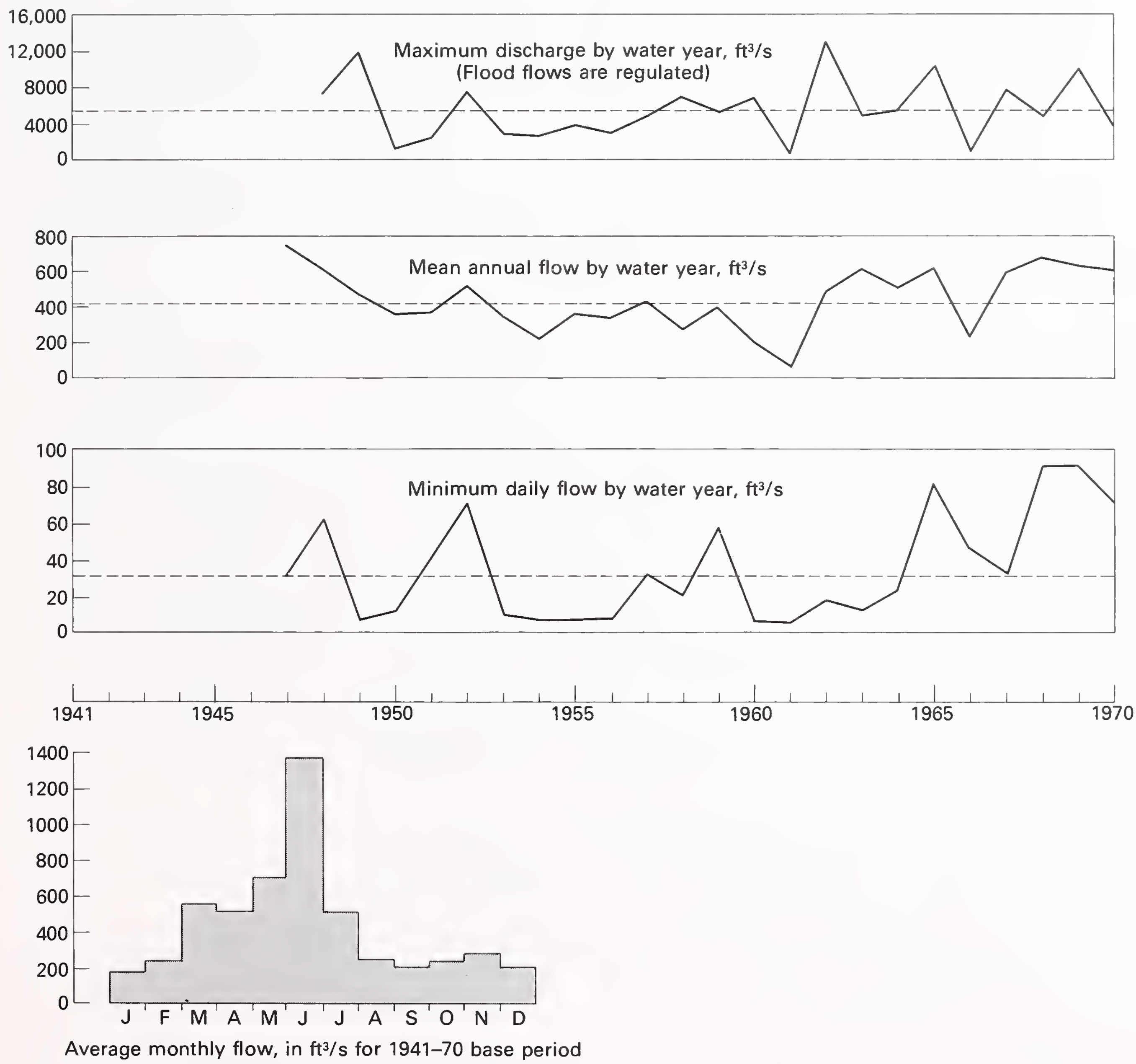


FIGURE II-6.--Flow data for the Tongue River at Miles City. Source: Montana Department of Natural Resources and Conservation, 1976.

flow of the Yellowstone River should preclude any shortage of water for diversions to Colstrip. In addition, Montana Power is required to maintain a 50-day supply of water for emergencies. This is done with a 2,800 acre-foot storage reservoir.

Consumptive use of water by municipalities in the designated region in 1978 was estimated to be 2,800 acre-feet, based on an assumed consumptive use of about 0.06 acre-feet per person per year, or about 50 gallons per person per day. The total water requirement is assumed to be 0.2 acre-foot per person per year or 180 gallons per person per day.

Sheridan has a direct-flow water right of 9 ft^3/s, which the City Engineer believes would serve a population of about 20,000. In addition, the city owns the rights to about 2,000 acre-feet of available storage and is constructing a 4-million-gallon (12.3 acre-foot) reservoir to store additional water for periods of high usage.

Other municipalities in the study area presently have sufficient supplies. Present and future municipal water requirements are shown in figure IV-1.

Water in the upper reaches of streams originating in the Bighorn Mountains and on the eastern flank of the Wolf Mountains is of suitable quality for most uses. In the lower reaches of some of these streams, the water quality is degraded by irrigation return flow, sewage, and ground-water inflow. At times during low flow, the quality is marginal, or possibly unfit, for some uses. The USGS (1977) and EPA (1977) reported that Prairie Dog and Goose Creeks and the lower reaches of the Tongue River in Wyoming have been most affected by this degradation. In other streams in the area, high concentrations of dissolved solids commonly render the water unfit for most uses. Table II-2 shows the quality of water in streams that could be affected by the proposed developments.

The chemical quality of the streams in the area varies with the time of year and the amount of precipitation in the contributing area. Streams, such as Sarpy, Armells, and Otter Creeks that drain the more arid parts of the area usually have concentrations of several thousand milligrams per liter of total dissolved solids--mainly sodium sulfate. The other streams have much lower concentrations of total dissolved solids--mainly sulfates and bicarbonates of calcium, magnesium, and sodium.

A principal source of dissolved solids in the rivers of the area is return water from irrigation. During periods of low flow, the total dissolved-solids content in the Tongue River may increase more than 200 percent as it passes through the irrigated area in Wyoming. Similar increases in dissolved solids are to be expected below irrigated areas.

The dissolved solids load from urban runoff in the area is unknown. Snowmelt runoff from Sheridan is of concern because of the relatively low flow, and therefore low dilution, in Goose Creek. Sheridan uses a mixture of clinker and urea for snow control on roads and thus does not have a problem from salt entering streams and damaging vegetation along roadways.

TABLE II-2.--Quality of surface water in selected streams, October 1975

[Source: U.S. Department of the Interior, 1976a; 1976b]

	Goose Creek below Sheridan, Wyoming	Tongue River near Dayton, Wyoming	Tongue River at State line, near Decker, Montana	Tongue River at Miles City, Montana
Discharge (ft^3/s)	73	78	204	231
Specific conductance (μmhos/cm)	850	270	800	1,020
pH	8.0	8.1	8.1	8.4
Dissolved oxygen (mg/L)	9.4	10.1	8.5	11.6
BOD (mg/L)	5.7	1.6	3.1	---
Calcium (mg/L)	79	37	74	62
Magnesium (mg/L)	52	12	46	54
Sodium (mg/L)	35	1.2	39	110
Potassium (mg/L)	4.8	1.0	4.2	5.6
Bicarbonate (mg/L)	360	150	300	281
Carbonate (mg/L)	0	6	0	5
Sulfate (mg/L)	180	3.3	220	360
Chloride (mg/L)	6.5	.0	4.3	5.9
Fluoride (mg/L)	.5	.2	.4	.3
Dissolved solids Sum of constituents	545	141	540	694
Suspended solids (mg/L)	32	12	20	---
Ammonia nitrogen (mg/L)	.82	.01	.00	---
Unionized ammonia (mg/L)	.016	0	0	---
Dissolved chromium (μg/L)	10	10	10	0
Dissolved iron (μg/L)	10	10	0	50
Dissolved manganese (μg/L)	30	10	30	10

At times, the ammonia content of the water in Goose Creek below Sheridan exceeds the recommended limit of 0.02 mg/L for fish. No adverse effects on the fish in this stream have been documented. The source of the ammonia appears to be Sheridan's sewage treatment plant. The urea used to clear snow breaks down in water to gaseous ammonia and carbon dioxide; however, these chemicals dissipate rapidly in flowing streams and thus do not appear to contribute to the ammonia problem.

Fecal coliform pollution is greatest in Goose Creek near Sheridan. The mean fecal coliform concentration below the sewage treatment plant is about 15,000 fecal coliform/100 milliliters. The concentration declines to about 5,000 near the confluence of Goose Creek with the Tongue River, to 750 in the Tongue River below the confluence, and to 185 in the Tongue River at the State line, which is below the upper limit of 200 recommended for water that is acceptable for swimming.

2. Ground Water

Recharge is mainly through sandy zones in the Fort Union Formation, coarse-grained alluvium, and clinker. Water in the near-surface aquifers is commonly "perched" by shale and other relatively impermeable materials that retard the downward movement of water, thereby creating local zones of saturation above the regional water table. Where such impermeable beds are exposed by erosion, ground water commonly is discharged as seeps and springs along bedding planes, joints, and fractures. Natural discharge of ground water is by upward leakage to the river valleys of the area. Ground water under artesian pressure is common in the river-bottom lands, and many deep wells drilled on the flood plain flow at the land surface.

Ground-water discharge to streams can be estimated from streamflow following the irrigation season. Of the minor streams in the area, many of which have drainages of 500 square miles or more, only three have substantial low flows indicating appreciable ground-water discharge--Rosebud, Squirrel, and Youngs Creeks, all of which originate in the Wolf Mountains, where precipitation and ground-water recharge is much higher than in other parts of the area. Flow in the Tongue and Powder Rivers increases during the fall because less water is diverted for irrigation.

Alluvium along the streams provide the shallowest aquifers. Most alluvium is too fine grained to yield much water; however, clean coarse-grained material locally may yield from several gallons per minute (gal/min) to several hundred gal/min along the rivers.

The aquifers most commonly used in the area are sandstone and coal beds in the Fort Union Formation. The sandstone beds are lenticular and generally do not extend more than a few miles, nor do they yield more than a few gallons of water per minute to wells. Sandstone aquifers are more prevalent in the Colstrip area than in the Decker area. Coal aquifers are more widespread than sandstone, but their ability to yield water varies from place to place. Most of the major coal beds

that are saturated and lie within a few hundred feet of the surface may yield as much as several tens of gallons per minute to wells. Wells several hundred feet deep that penetrate fractured rocks may produce 100 gal/min or more. Permeable beds are less common in the Lebo Shale Member than in the overlying Tongue River or the underlying Tullock Members of the Fort Union Formation.

Although clinker is usually very permeable, it is usually unsaturated, and most wells drilled into clinker do not yield water. A notable exception to this is near the Tongue River Reservoir, where the damming of the river has raised the water table above the base of the clinker. Wells drilled into the clinker in this area may yield several hundred gal/min.

The lower part of the Hell Creek Formation (Upper Cretaceous age) comprises permeable sandstones, which, along with the underlying Fox Hills Sandstone, form the shallowest continuous aquifer believed to underlie essentially the entire area. In some areas, this aquifer yields industrial supplies of 100 to 200 gal/min. Although this aquifer has not been tested in the western part of the study area, it may, at least locally, be the shallowest source of consistent supplies of 100 to 200 gal/min. Broadus obtains its water from this aquifer. Water from the Hell Creek-Fox Hills aquifer usually is of the sodium bicarbonate type; it is extremely soft and suitable for drinking, but its excessive sodium content makes it generally unsuitable for irrigation.

The formations that underlie the Hell Creek-Fox Hills aquifer and overlie the Madison Limestone are generally poorly permeable and yield poor quality water.

Large yields (as much as 1,000 gpm) are obtained from the Madison Group within 20 miles of the Wyoming-Montana State line (in the Bell Creek oil field). But wells in the Madison Group at Colstrip, at the Sarpy Creek mine, and along the Powder River north of Powderville yield less than 100 gal/min. Wells to the Madison at Decker would be about 9,200 feet deep. The water from the Madison in this part of the area probably would contain 1,000 to 2,000 milligrams per liter (mg/L) total dissolved solids.

The chemical quality of the ground water in the area is highly variable. Most of the shallow ground water from the the Fort Union Formation is of the sulfate type and contains several thousand mg/L of total dissolved solids. In some areas, ground-water contains lead concentrations of almost twice the recommended maximum Public Health Service standard of 0.05 mg/L. The source of the lead is unknown. The ground water in most shallow wells is has high concentrations of magnesium and calcium, and therefore it tends to be unfit for irrigation. Water from deep wells contains very little magnesium and calcium, but it has a high sodium content, which makes it also undesirable for irrigation.

Water from deeper wells is typically lower in total dissolved solids than that from shallow wells. The water is of the bicarbonate type and

does not contain excessive lead, but its fluoride concentration commonly exceeds the maximum level of 2.2 mg/L recommended for human consumption. The highest measured concentration of fluoride is 7 mg/L.

Industrial waste water from the various sludge ponds at Colstrip may be recharging the ground-water system, but no adverse effects due to such recharge are known.

The largest use of ground water in the study area is at the ongoing mines (fig. IV-1). The water, obtained from seepage pumped from the mine pit and from shallow wells, is used for dust control, equipment washing, sanitary facilities, and drinking. Mines in the Colstrip area generally derive most of their water from sandstone aquifers, in the Decker area, from aquifers in coal beds and clinker.

Ashland and Broadus use ground water for municipal supplies. Ashland uses about 100 acre-feet per year and Broadus about 180 acre-feet. Numerous ranchers and farmers depend on ground water for domestic and stock use.

C. CLIMATE

The semiarid climate of the study area is characteristic of the continental steppes of the Northern Great Plains, in which the warmest months are the driest. The area has cool moist springs, warm dry summers, and cold moist winters. There are large periodic variations in annual and seasonal precipitation and temperature. The last 10 years have had generally optimum moisture and mild temperatures, but droughts can be expected to recur.

Summers have warm sunny days and cool nights, owing to the moderately high elevation and clear, thin atmosphere. The weather typically does not become severely cold until December. Winters are dominated by high-pressure Arctic air masses that move southward along the east front of the Canadian Rockies, and by the northern Pacific air masses that bring moisture. Cold waves occur almost every winter with varying severity; they are often broken by extended periods of warm weather, usually due to chinook winds. Occasionally, the warm periods are terminated equally abruptly by blizzards. Most precipitation falls during late spring and early summer when warm, moist air drawn northward from the Gulf of Mexico rises across the high plains and is progressively cooled.

1. Precipitation

Precipitation in the area (fig. II-7) varies with elevation and with season. Mean annual precipitation is about 12 inches at low elevations, about 15 to 16 inches at high elevations. Mean annual precipitation at Colstrip is about 15 inches; at Decker, about 12 inches. Throughout the area, about 50 percent of the total precipitation falls in spring, about 20 percent in winter (fig. II-8). There are brief fall showers. Of the

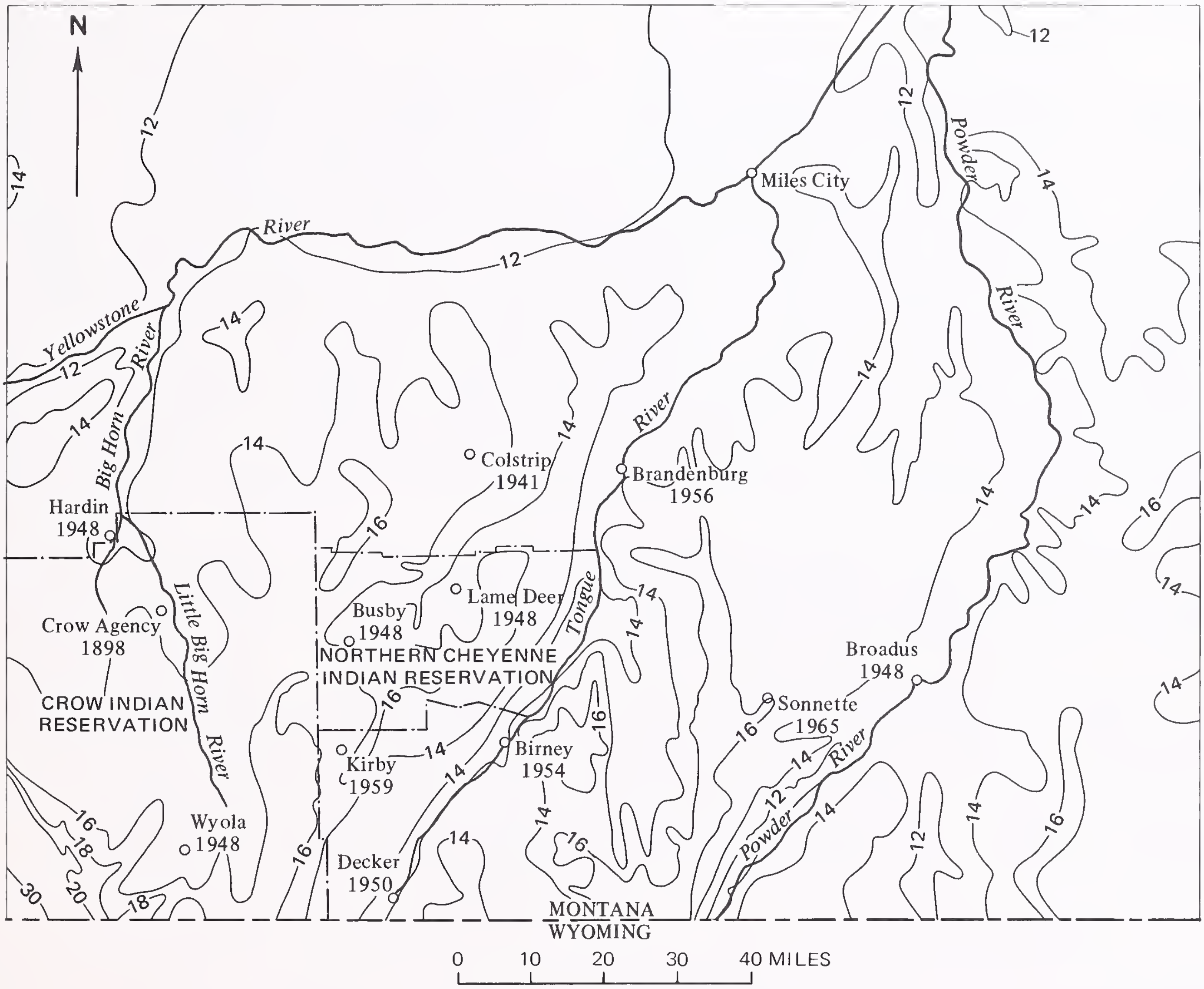


FIGURE II-7.--Isopleths of annual mean precipitation in the northern Powder River basin, 1953-67, showing first year of record at selected weather stations.

areas where mining is proposed or projected, Colstrip has the greatest May-June precipitation, averaging 5.0 inches, and Decker the least, averaging 4.35 inches.

In an average year, 95 days receive precipitation. Spring thunderstorms provide a disproportionate amount of precipitation. About half of the total annual precipitation falls on 8 days as 24-hour storms greater than .45 inch. At Colstrip, there is a calculated probability that a 2-inch, 24-hour storm will occur about once every 10 years (or about once every 12 years, in April, May, or June), and a 3-inch storm can be expected once every 200 years (table II-3). The largest recorded 24-hour storm at Colstrip was 3.77 inches in June 1974 (U.S. Department of Commerce, 1971). The frequency of large storms at Decker appears to be similar to Colstrip. Such large storms generally do not occur as cloudbursts during periods of drought, but during periods of above-average precipitation (fig. II-9). For example, annual precipitation at Billings was above average from about 1938 to 1942. During this period, as much as one-third to one-half the annual precipitation fell in amounts greater than 1 inch.

Hail accompanies summer thunderstorms 40 to 70 times per 20-year period (Montana Department of Natural Resources and Conservation, 1974). Tornados are rare and short in duration.

Total annual snowfall in the study area ranges from about 30 to 50 inches (Montana Department of Natural Resources and Conservation, 1974). Snowfall has been reported as late as June 8th (2 inches) and as early as September 8th (6 inches) at Colstrip. Figure II-10 shows the probability that snow of a certain depth will stay on the ground for a certain number of days. For example, once every 25 years one can expect 8 inches of snow to stay on the ground for 30 consecutive days.

2. Temperature

Mean annual temperature and seasonal patterns in temperatures are similar throughout the area. Mean annual temperature is about 45°F. Temperatures are lowest in January, averaging about 8°F, and highest in July, averaging about 90°F (fig. II-11). High mid-summer temperatures terminate the effective growing season. Relative humidity is lowest in July and highest in winter. The freeze-free season is about 135 days near Forsyth, about 115 days near Colstrip, 90 to 100 days--the shortest in the area--west of Decker.

3. Interrelations and Trends

The study area has had above-average precipitation in the past 10 years (fig. II-12). From 1920 to the present, mean annual precipitation increased by almost an inch per decade, and since the 1940's, May-June precipitation has increased by about 12 percent. From 1971 to 1975 at Colstrip, mean annual precipitation was fourth highest of 44 possible

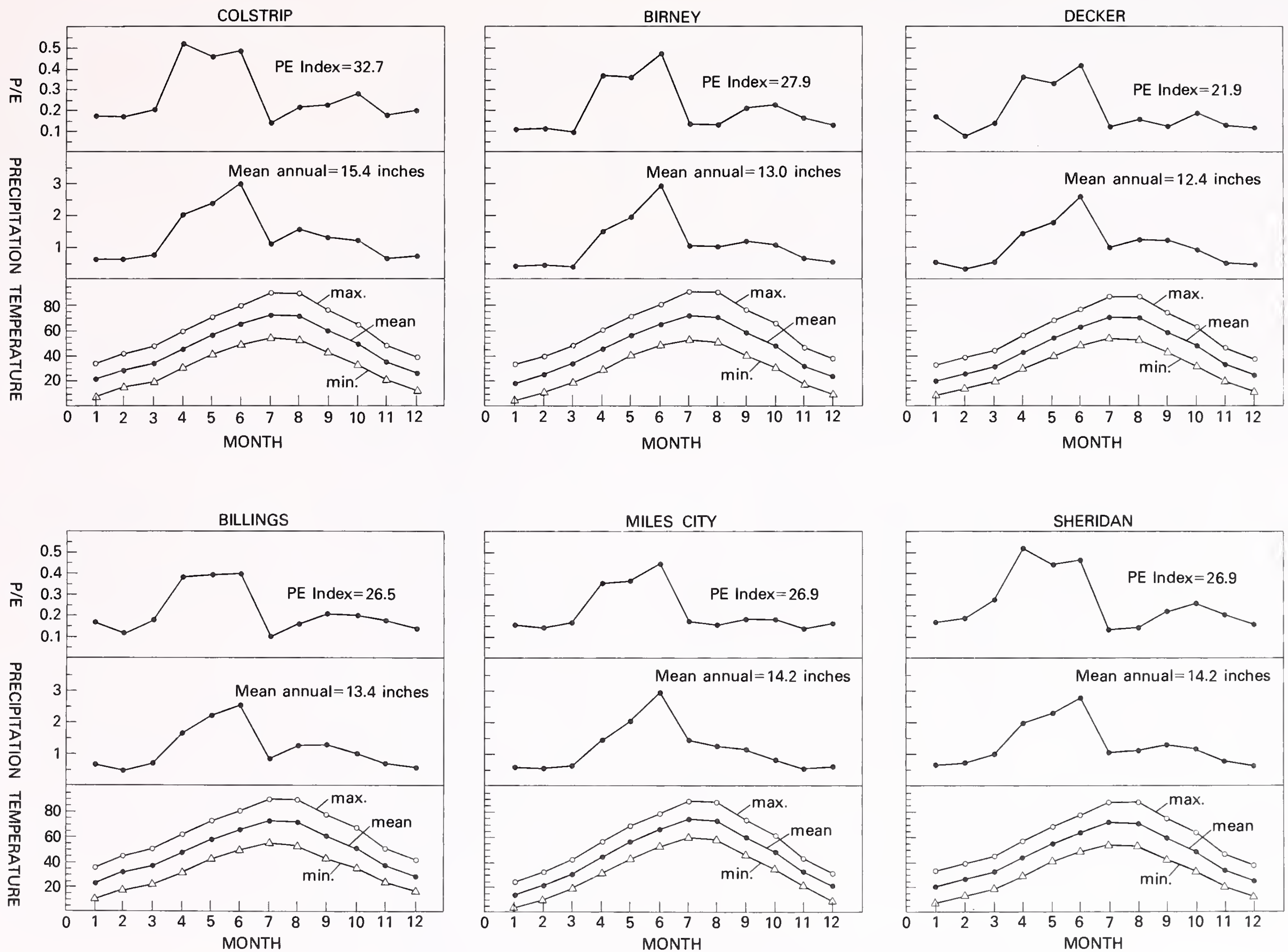


FIGURE II-8.--Seasonal variation in precipitation, temperature, and effective precipitation coefficients at selected weather stations in the northern Powder River basin (1950-76).

TABLE II-3.--Calculated probability of the largest 24-hour or 6-hour rainstorm expected during various lengths of time

24-hour precipitation

Station name	First year	Last year	Number of years of record	Size of largest storm (inches), Number of years considered: 2	5	10	25	50	100	200
Broadus-----------	1948	1976	29	1.19	1.65	1.97	2.41	2.76	3.13	3.51
Colstrip----------	1948	1976	28	1.25	1.74	2.04	2.38	2.62	2.83	3.03
Wyola-------------	1948	1976	29	1.28	1.66	1.91	2.20	2.42	2.62	2.83
Sonnette----------	1965	1976	12	1.64	2.26	2.36	2.40	2.40	2.40	2.40
Lame Deer---------	1948	1976	29	1.03	1.46	1.74	2.09	2.34	2.58	2.83
Kirby-------------	1959	1975	17	1.35	2.16	2.74	3.51	4.12	4.74	5.38
Hardin------------	1948	1976	29	1.08	1.57	1.93	2.43	2.84	3.28	3.74
Billings----------	1894	1976	79	1.34	1.91	2.27	2.71	3.03	3.33	3.62
Birney------------	1954	1976	23	1.27	1.77	1.91	1.98	2.00	2.01	2.02
Crow Agency-------	1898	1976	77	1.25	1.78	2.15	2.66	3.06	3.48	3.93
Decker------------	1950	1976	22	1.15	1.74	2.19	2.84	3.37	3.95	4.59
Brandenberg-------	1956	1976	21	1.25	1.75	2.11	2.61	3.00	3.43	3.88
Busby-------------	1948	1976	29	1.19	1.81	2.15	2.51	2.72	2.90	3.05

6-hour precipitation (Miller and others, 1973)

Station name	Size of largest storm (inches), Number of years considered: 2	5	10	25	50	100
Colstrip------	1.00	1.30	1.60	2.00	2.20	2.40
Lame Deer-----	1.00	1.30	1.55	1.95	2.20	2.40
Birney--------	0.90	1.20	1.40	1.80	2.00	2.30
Decker--------	1.00	1.35	1.60	1.95	2.20	2.40

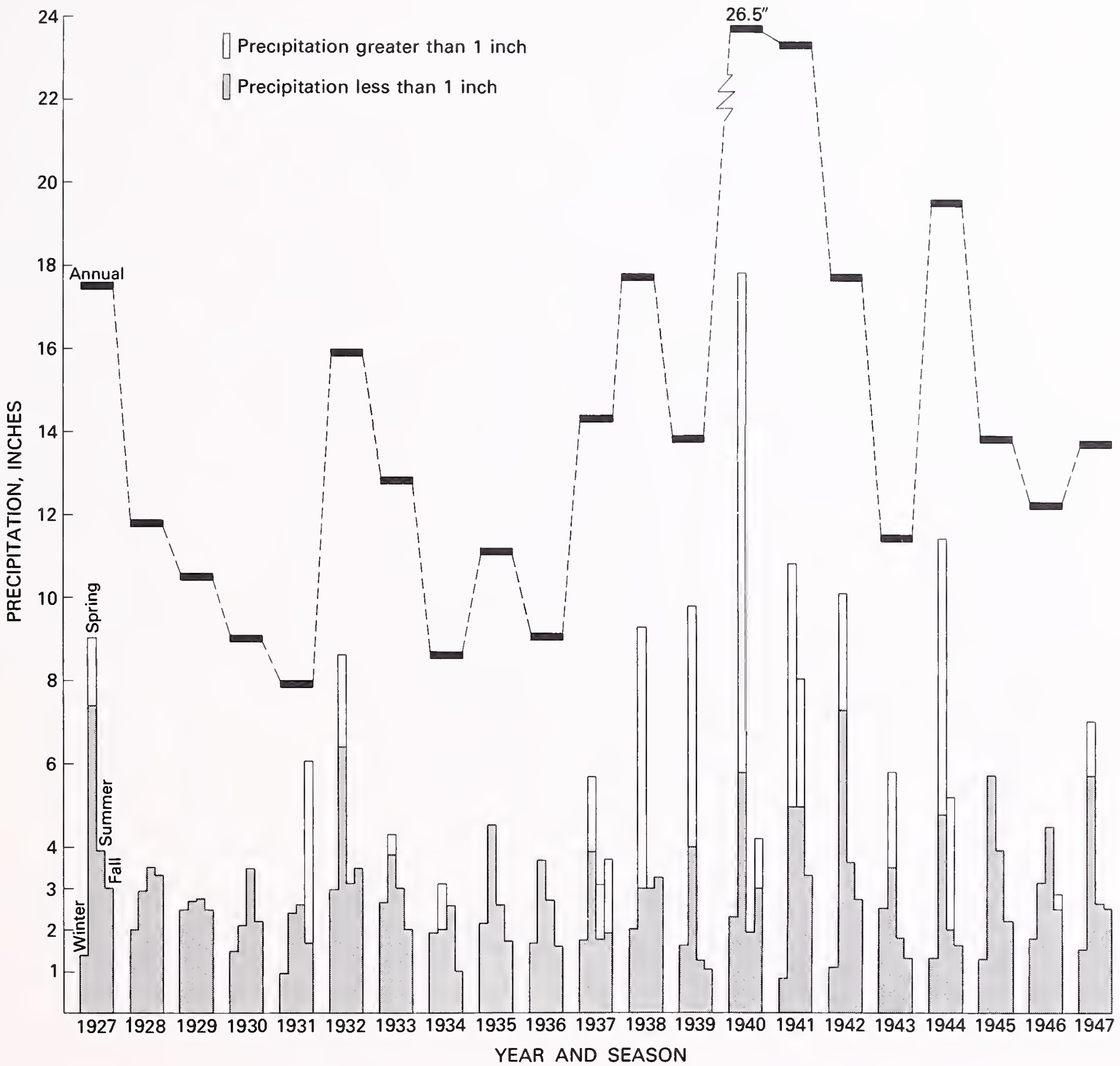


FIGURE II-9.--Seasonal precipitation at Billings, Montana (1927-47).

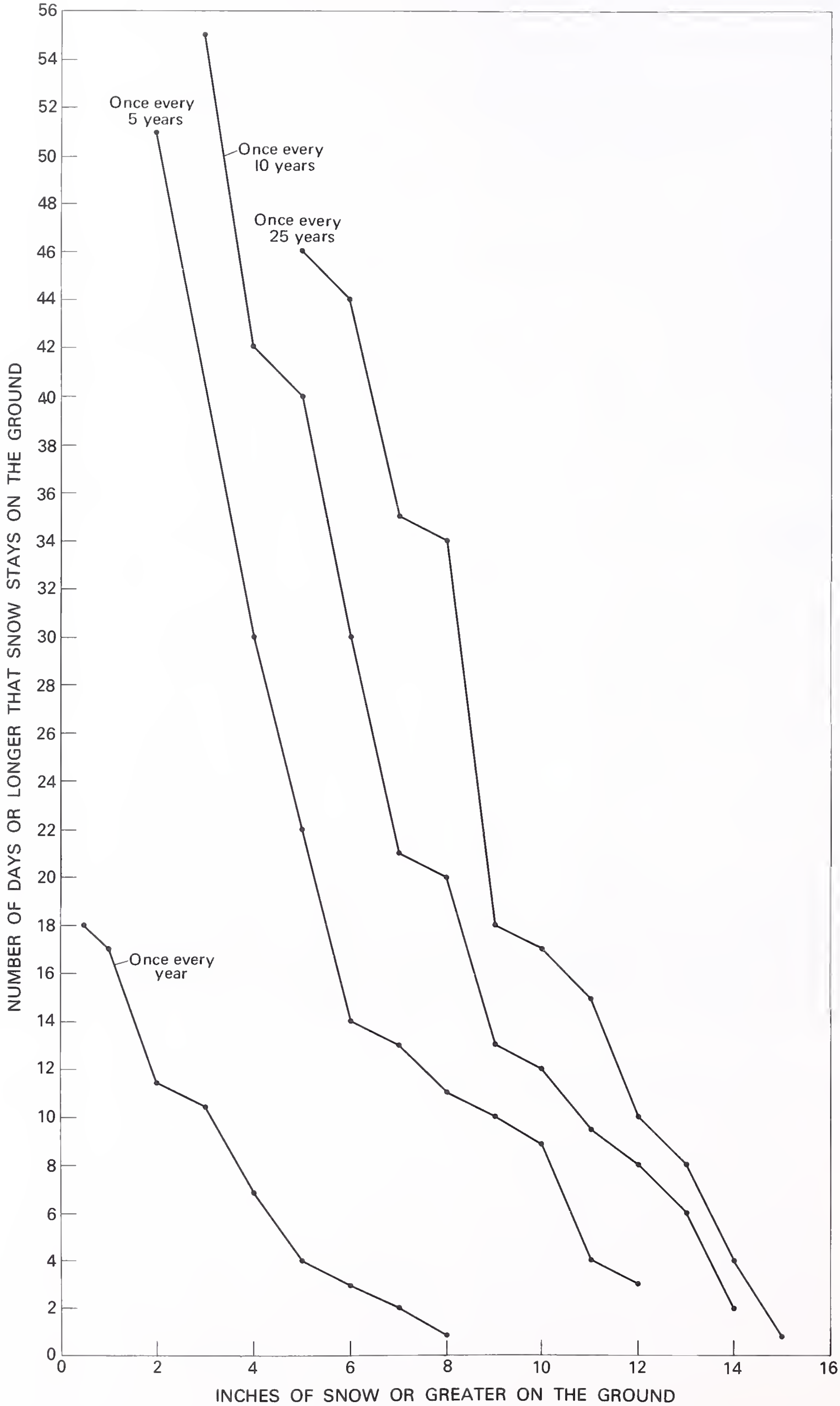


FIGURE II-10.--Temporal snow depth probabilities at Colstrip, Montana (1948-76).

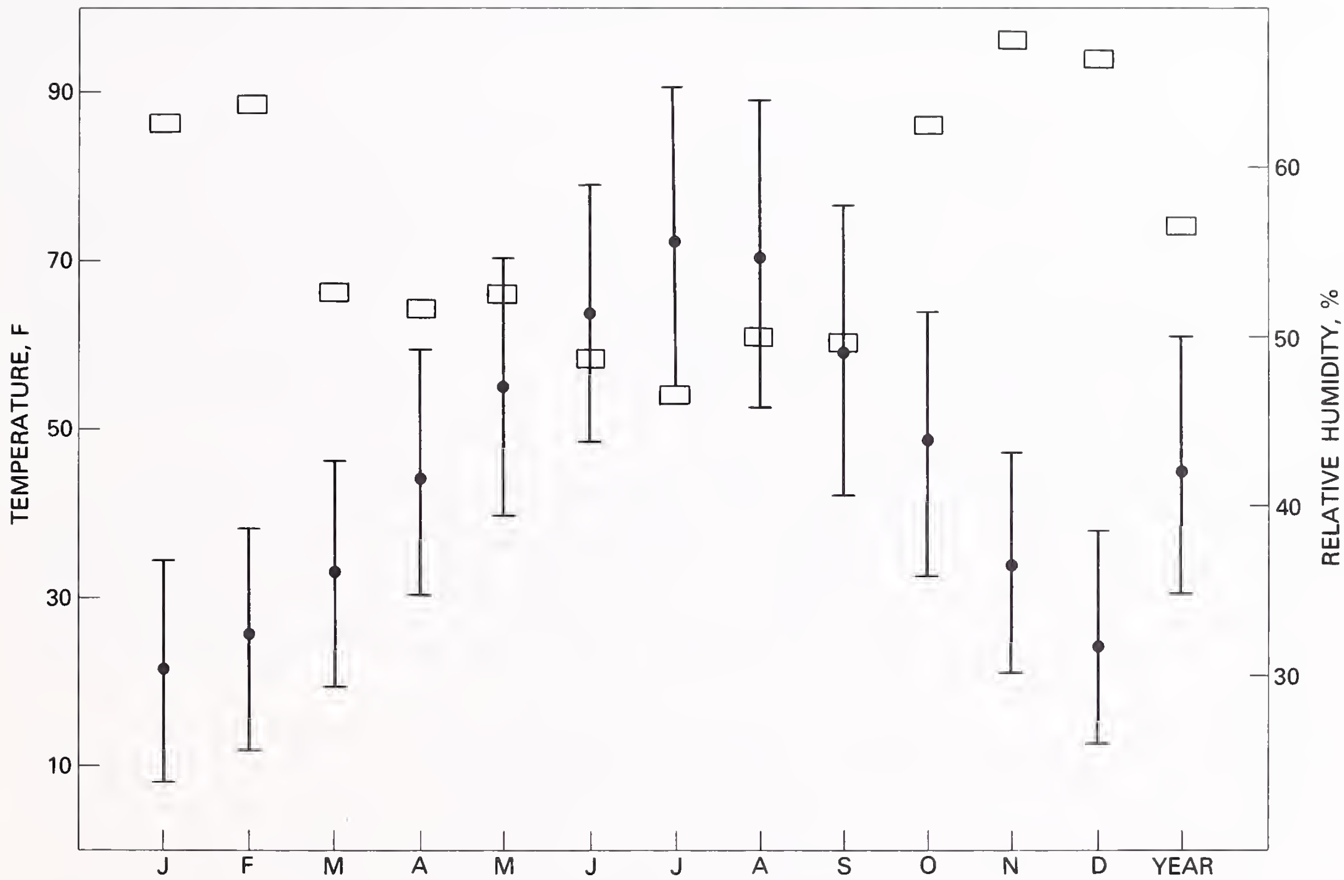


FIGURE II-11.--Seasonal variation in percent relative humidity (open boxes), mean temperature (dots), and mean maximum and minimum temperatures (horizontal lines at ends of vertical bars) at Colstrip, Montana.

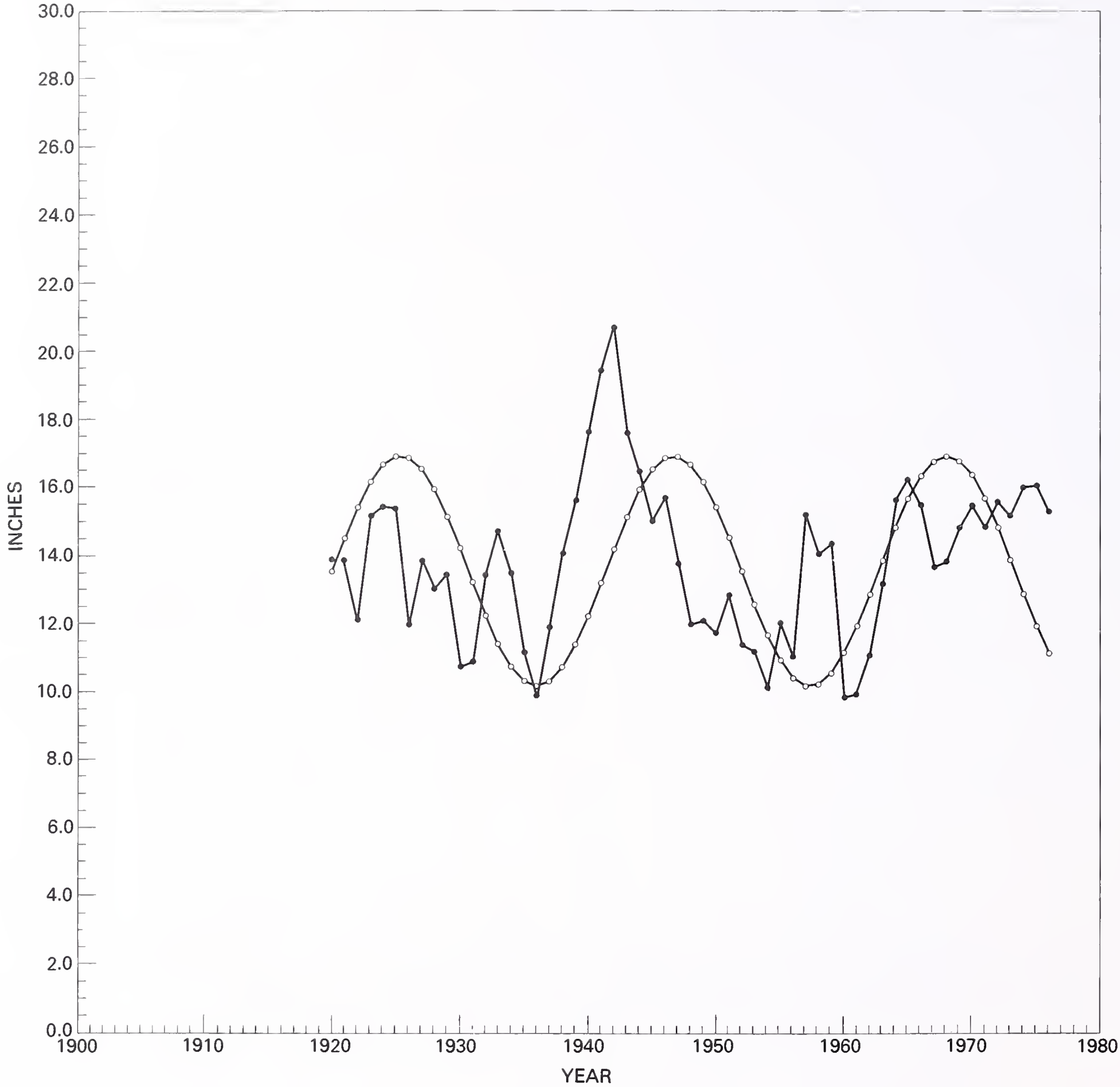


FIGURE II-12.--Periodicity of precipitation in the northern Powder River basin. Long-term precipitation data are from Billings, Crow Agency, Busby, and Miles City (1920 to 1976), and are superposed on assumed 21-year cycle.

5-year periods, and the mean growing-season precipitation was fifteenth; at Crow Agency, the mean annual precipitation was second, and the mean growing-season precipitation was the highest ever recorded (Montana Department of State Lands, 1977). At Colstrip, mean annual precipitation in the 1940's was 13.6 inches compared with 17.9 inches from 1971 to 1976. At Decker, mean annual precipitation in the 1950's was 11.9 inches compared with 14.1 inches from 1971 to 1976.

Analyses[4] of the 56 years of precipitation data from Billings, Crow Agency, and Miles City strongly suggest the possibility that this precipitation is the highest expectable in the study area in terms of the historic record, and, thus, that in the next few years precipitation may well begin to decline. (See figure II-12.) In 10 to 20 years, precipitation could well reach a minimum comparable to that in the 1930's--the lowest expectable in terms of the historic record. However, the historic record is very short compared with possible longer term climatic fluctuations.

During the period of record, May, June, and August temperatures were high when precipitation was low and vice versa, notably during the dry 1930's (fig. II-13) and the wet 1970's. High temperatures have exacerbated droughts and contributed to failures of wheat crops in the 1930's. . Favorable temperature and moisture conditions in the 1970's have probably aided revegetation of mined lands. (See Vegetation, chapter IV.)

In the summer, when precipitation is at a minimum, temperatures are warmest (fig. II-8). This largely accounts for the low precipitation-effectiveness index, classifying the area as semiarid (Thornthwaite, 1931). Potential evapotranspiration, which measures the effect of growing season length, wind speed, temperature, and precipitation on movement of water through the ecosystem, is higher along the river courses than in the uplands. Along the Tongue River near Decker, potential evapotranspiration is slightly greater than 20 inches; along the Yellowstone River at Miles City, slightly less than 20; in the Wolf Mountains and on the Ashland Division of the Custer National Forest, as high as 23.5.

4. Upper Winds

Upper winds are generally from the west. Mean seasonal wind speeds range from 12 to 23 miles per hour at 10,000 feet and 23-35 miles per hour at 18,000 feet. Fall and winter winds are fastest and tend to blow from the northwest; spring winds blow from the west and summer winds from the southwest. These patterns reflect the predominance of weather systems from the cold polar and Arctic regions in late fall and winter, the Pacific Ocean in the spring, and the Gulf of Mexico in the summer (Northern Great Plains Resources Program, 1974).

---

[4]On file at the Montana Department of State Lands, Capitol Station, Helena, MT 59601

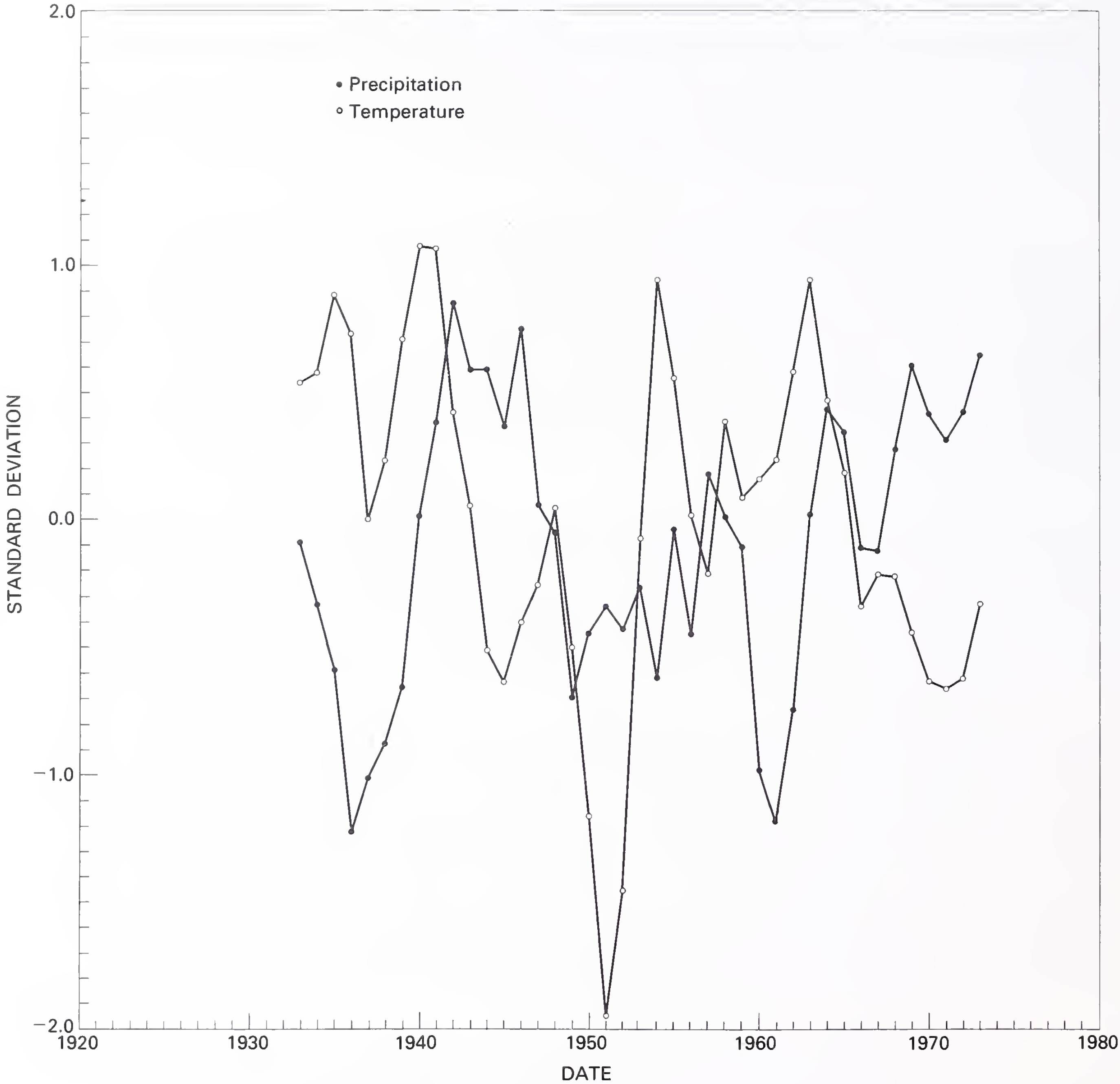


FIGURE II-13.--Three year running averages of annual precipitation and annual temperature at Billings, Crow Agency, Miles City, and Sheridan, 1930 to 1976, expressed as positive and negative standard deviations around the mean.

5. Surface Winds

Mean annual wind speeds range from 8 miles per hour at Sheridan to about 11 miles per hour at Billings and Colstrip. Mean seasonal wind speeds appear to peak in the spring. Sheridan, Wyoming, has the highest wind speeds recorded in the Northern Great Plains--84 miles/hour, recorded in the fall (Northern Great Plains Resources Program, 1974).

a. Colstrip area surface winds

Prevailing winds near Colstrip are from the west-northwest (fig. II-14). During the warmer months there is also a southeastern wind pattern. Surface airflow (first 30 feet) is affected by local topography. At the Big Sky mine, surface airflow is predominantly from the southwest through the northwest, approximating the axis of the drainage (fig. II-14). Diurnal fluctuation in surface airflow is most significant during the warmer months, with upvalley flow during the day and downvalley flow at night. During the winter, diurnal variation in surface airflow is negligible; northwest winds prevail at Colstrip, southwest winds at Big Sky. One wind direction may persist more than 12 hours during winter (Super and others, 1973). This would tend to increase the exposure time of downwind areas to pollutants.

Analysis of wind roses at three meteorological stations near Colstrip shows that surface winds are likely to blow the same direction across all the existing, proposed, and projected mines and the power units during (1) the early morning (0100-0600 hours) when winds are from the northwest, (2) in the afternoon (1300-1800 hours) when winds are from the west, and (3) in the evenings (1900-2400 hours) when winds are either from the west or west-northwest (State open-file report). Worst-case air pollution episodes would occur on elevated terrain downwind of the Colstrip generating units in the winter, when inversions during the early morning are common and when the wind is from the northwest. (See ensuing discussion of inversions and mixing heights.)

Average wind speeds range from about 14 miles per hour in the upper wind patterns (300 feet) to 7 miles per hour at the surface (30 feet) (table II-4). Calm periods are rare. Wind speeds greater than 40 miles per hour have been recorded in the last 3 years at all levels, but they also are rare.

6. Regional Mixing Heights and Wind Speeds

Air pollution generally appears to disperse less rapidly in southeastern Montana than in any other sector of the State. This is largely due to below-average mixing heights in eastern Montana and to unusually high inversion frequency (Holzworth, 1972; Super and others, 1973).

Diurnal changes in mixing heights are marked in eastern Montana, with low mixing heights in the mornings and much higher mixing heights in the afternoon (table II-5). Morning mixing heights and wind speeds

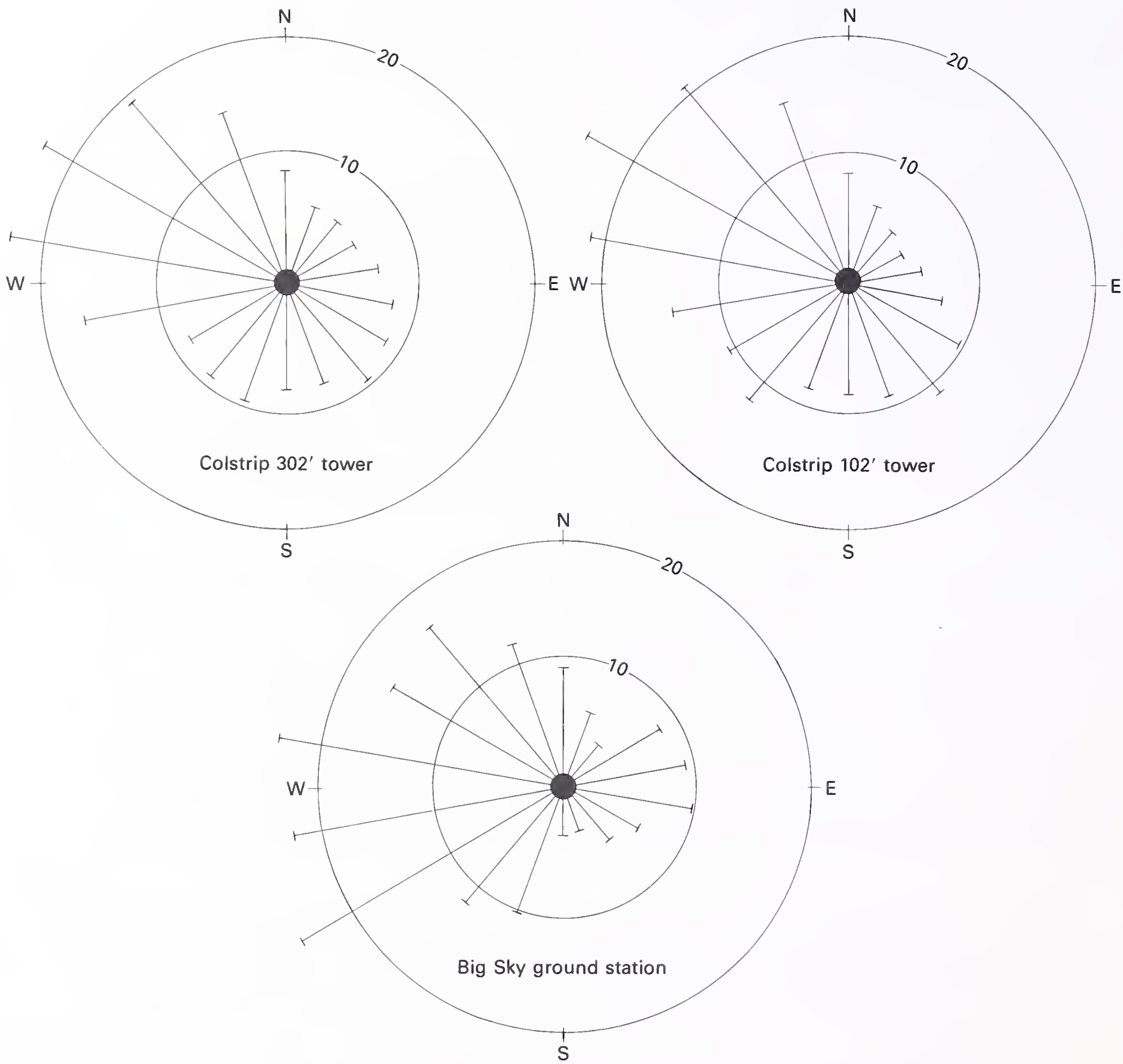


FIGURE II-14.--Annual wind roses at Colstrip weather tower and at Big Sky mine ground station, November 1974 through October 1977.

TABLE II-4.--Wind speed frequency distribution during the period 11-1-74 to 10-31-77 at Colstrip and Big Sky, Montana

Wind speed class (mi/hr)	Percent frequency		
	Colstrip 302-ft tower	Colstrip 102-ft tower	Big Sky ground
Calm----------	0.2	0.5	1.0
1-3----------	4.2	5.6	20.8
4-6----------	10.1	14.9	26.6
7-10---------	19.5	29.1	25.6
11-16--------	32.8	31.2	19.2
17-21--------	17.8	11.5	5.0
22-27--------	10.6	5.7	1.5
28-33--------	3.8	1.3	0.3
34-40--------	0.9	0.2	---
41-45--------	0.1	---	---
Mean wind speed----	13.8	11.5	7.0

TABLE II-5.--Mean seasonal mixing heights and corresponding mean wind speeds in the morning and afternoon in southeastern Montana

[Source: Holzworth, 1972]

		Annual	Winter	Spring	Summer	Fall
Morning	Height (ft)---	985-1,310	980	1,310	980	980
	Speed (mi/hr)-	8-13	11	11	11	10
Afternoon	Height (ft)---	5,250-6,560	2,625	6,560-9,190	9,190	5,250
	Speed (mi/hr)-	16	15	18	16	17

do not vary greatly with the seasons, whereas afternoon heights and speeds are lowest in winter and highest in spring and summer (table II-6).

TABLE II-6.--Total number of episode-days in 5 years with selected mixing heights, wind speeds, and no significant precipitation, lasting at least 2 days or 5 days in eastern Montana

[Source: Holzworth, 1972]

Mixing height (ft)	Number of episode-days lasting 2 days			Number of episode-days lasting 5 days	
	Wind speed (mi/hr)			Wind speed (mi/hr)	
	4.5	9.0	13	9	13
1,640	0	50	50-100	0-25	25
3,280	0	20-50	100	0-25	25
4,920	0-25	25-100	100-200	0-50	20-100
6,560	0-25	100-200	200	0-50	20-100

The prolonged duration of depressed mixing depth and low wind speed may concentrate air pollutants. Table II-6 shows the number of periods in which such events lasted 2 days or 5 days. All of these periods occurred during the winter.

Data from the meteorological tower at Colstrip indicate that inversions are very frequent. Inversions occur every month of the year (table II-7) but are prolonged in the winter and broken up in the morning during spring and summer. Inversions are most likely to break up between 8 a.m. and 3 p.m. at Colstrip. Inversion break-up would be most likely to bring high concentrations of pollutants to the ground in winter, when top heights of inversions are lowest (table II-8). However, early morning (4-5 a.m.) inversions are more frequent in spring, and inversion break-ups occur almost every morning around 8 a.m. (State task force open-file report). Spring afternoon mixing heights vary considerably, suggesting the turbulence of the atmosphere during this season (table II-9).

TABLE II-7.--Percentage of time during each month that inversions occur at Colstrip, Montana

[Source: State task force open-file report]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Percent----	59	49	39	34	40	33	32	36	43	45	56	60

TABLE II-8.--Frequency of top heights of ground based inversions, by season

[Source: Montana Department of Natural Resources, 1974]

Inversion height (ft)	Winter	Spring	Summer	Fall
0-500-----	16	12	14	12
500-1,000---	30	46	38	39
1,000-1,500---	27	16	35	24
1,500-2,000---	27	24	5	13
2,000-2,500---	---	2	5	10
2,500-3,000---	---	---	3	2

TABLE II-9.--Midafternoon mixing depth heights, by season

[Source: Montana Department of Natural Resources, 1974]

Inversion height (ft)	Winter	Spring	Summer	Fall
0-1,000---	57	---	---	12
1,000-2,000---	17	6	---	38
2,000-3,000---	11	13	---	23
3,000-5,000---	---	11	---	17
5,000-10,000--	---	35	33	5
10,000----	---	35	67	5

7. Clouds and Sunshine

The region receives about 50 percent of possible sunshine, except in the winter when cloud cover increases. Average daily solar radiation is about 371 Langleys (gram calories/cm^2). Skies are clearest during the long days of summer, with about 500 Langleys of solar radiation per day.

D. AIR QUALITY

The air quality of the six-county study area is generally excellent, except for local fugitive dust and gaseous emissions from strip mines and the plume from Colstrip units 1 and 2. Rural areas and most

towns have pristine air. Maximum visibility ranges from 350 miles at Colstrip to 35 miles near Decker; however, fugitive dust has become a problem near the mines at Colstrip and Decker. Particulate air-quality standards in these areas have been violated, and approximately 120 square miles in the Colstrip area has been classified as a nonattainment area for total suspended particulates (TSP). Violations of the standards for sulfur dioxide downwind of the Colstrip power generating units have not been recorded.

1. Emissions from Area Sources

Because the climate in eastern Montana is semiarid, fugitive dust can be a major air pollution problem (table II-10). The sources are unpaved roads, fallow fields, overgrazed land, exposed soft rock outcrops, towns, and strip mines. TSP samplers in rural areas record annual geometric means between 11 and 21 $\mu g/m^3$. The 24-hour maximum concentration in 1 year may range from 50 to 243 $\mu g/m^3$. Towns in eastern Montana also have clean air: annual geometric means average around 15 $\mu g/m^3$. Typical TSP concentrations at strip mines are around 50 $\mu g/m^3$; the 24-hour averages exceed the standard more often than in towns or rural areas. Concentrations vary throughout the year at both strip mines and rural areas; they peak in July, August, and September, probably because of low humidity.

TABLE II-10.--TSP annual geometric means and maximum 24-hour averages from selected sampling sites in the region (1977 data)

County and site name	Site type	Annual geometric mean, $\mu g/m^3$	Maximum 24-hour average, $\mu g/m^3$
Rosebud:			
WECo #4------	Industrial-------	50	422
WECo #2------	Industrial-------	48	236
BN site------	Industrial-------	25	95
Colstrip-----	Industrial town--	81	306
Hay Coulee[1]--	Rural------------	13	57
McRae--------	Rural------------	17	102
Fisher Butte-	Rural------------	17	243
Custer:			
Miles City---	Town-------------	16	45
Big Horn:			
Rural Hardin-	Rural------------	17	108
Morton-------	Industrial-------	40	159
Spring Creek-	Rural------------	21	
Shell-Pearl[2]-	Rural------------	11	50
Powder River:			
Broadus------	Town-------------	14	275

[1] August 1977 to January 1978 inclusive.
[2] 1976 data.

Colstrip has a serious fugitive dust problem: both the annual geometric mean and the 24-hour maximum TSP concentrations are in violation of the National Ambient Air Quality Standard (NAAQS, table III-2). Colstrip is the only nonattainment area for TSP in the Coal Area, Air Quality Maintenance Area (AQMA). Most of the dust apparently comes from the Rosebud mines (PEDCo, 1978), notably from unprotected coal handling facilities (fig. II-15) and from uncovered coal piles. The handling of coal at the Rosebud mine is also poorly protected from wind erosion (fig. II-16). The problem is most severe during windstorms (fig. II-17).

Under law, nonattainment areas may not create new sources of particulates, and measures must be taken to control present dust-emitting sources. (See chapter III.) Reducing particulate emissions within the town of Colstrip probably will not be sufficient to offset major new sources of TSP associated with Colstrip units 3 and 4. The strip mines and particularly the coal handling facilities, not the town, are the major sources of particulates (PEDCo, 1978; MDHES hearing record, 1978). Figure II-15, an aerial view of the uncovered coal-handling facilities at Rosebud Area "A" 3 days after a light snowfall in January 1979, shows much more dust on the ground than at the nearby Big Sky mine (fig. II-18) and Absaloka mine (fig. II-19), which have covered coal handling facilities.

FIGURE II-15.--Area A loadout at the Rosebud mine, Colstrip, January 17, 1979, 3 days after last snowfall.

FIGURE II-16.--Lowering boom at the area A loadout pile, Rosebud mine, April 1978.

FIGURE II-17.--Coal dust storm over the trailer court and town, Colstrip.

FIGURE II-18.--Big Sky mine and the Rosebud mine loadout, January 17, 1979, 3 days after last snowfall.

FIGURE II-19.--Absaloka mine loadout, January 17, 1979, 3 days after last snowfall.

Dustfall, a measure of particulates which settle out of the air, has violated the Montana guideline (15 tons/mi^2/month) in Forsyth, Colstrip, Miles City, and Broadus (fig. II-20). The elevated dustfall in Forsyth and Miles City may be due to relatively high population density and to train traffic; those in Broadus, to relatively high agricultural activities; those in Colstrip, mainly to the Rosebud mine.

Most gaseous emissions from fuel combustion at strip mines are carbon monoxide and nitrogen dioxide (table II-11). At the Rosebud and Decker mines, mean annual 1978 concentrations of CO and NO_x within a mile-wide square centered over the mines were probably on the order of 0.5 and 0.4 parts per million (ppm), respectively.

Table II-12 shows estimated gaseous emissions from population-related sources (automobiles, home heating, construction, etc.). All area emissions resulted in insignificant concentrations, except for carbon monoxide (CO) in Sheridan, Wyoming, which probably resulted in mean annual CO concentrations of about 12 ppm.

Concentrations of trace elements in rural airsheds are extremely low (U.S. EPA, 1976; Gelhaus, 1976; EG & G, Environmental Consultants, 1976).

2. Emissions from Mobile Sources

Unit coal trains produce air pollution from combustion of locomotive diesel fuel and from loss of coal dust off of uncovered coal cars. Nitrogen oxides are the most abundant at approximately 40,000 lb/mile/year along the railway corridor from Colstrip to Miles City, and 46,000 lb/mile/year from the Decker area south toward Sheridan. (See table IV-6.) The amount of coal dust lost from unit trains is highly uncertain, and probably ranges from 0.50 to 1,000 tons/mi/year along the first 50 miles of transit north from Colstrip. (See table IV-5.) South of the Decker area, emissions are probably less, because the Decker Coal Company coats its coal with hot oil spray.

3. Emissions from Acute Fumigations

Air pollutants from faulty blasts or coal fires temporarily create hazardous driving conditions, as do fugitive dust clouds from poorly coordinated blasts (Grim and Hill, 1974). For periods of hours several times each year, visibility on FAS 314 near Decker is near zero. During inversions common to the area, gaseous emissions disperse less readily and are a health hazard.

The Monarch mines in Sheridan County have been burning out of control for years. These fires yield carbon disulfide, carbon oxysulfide, methane, helium, carbon dioxide, and possibly hydrogen sulfide (Dunrud and Osterwald, 1978). Carbon monoxide may range from a trace to 3,500 ppm at the source. Since these emissions are usually accompanied by steam, acid misting by transformation of sulfurous compounds may occur. Vegetation and animals downwind of these coal fires or faulty blast plumes suffer acute air pollution injury.

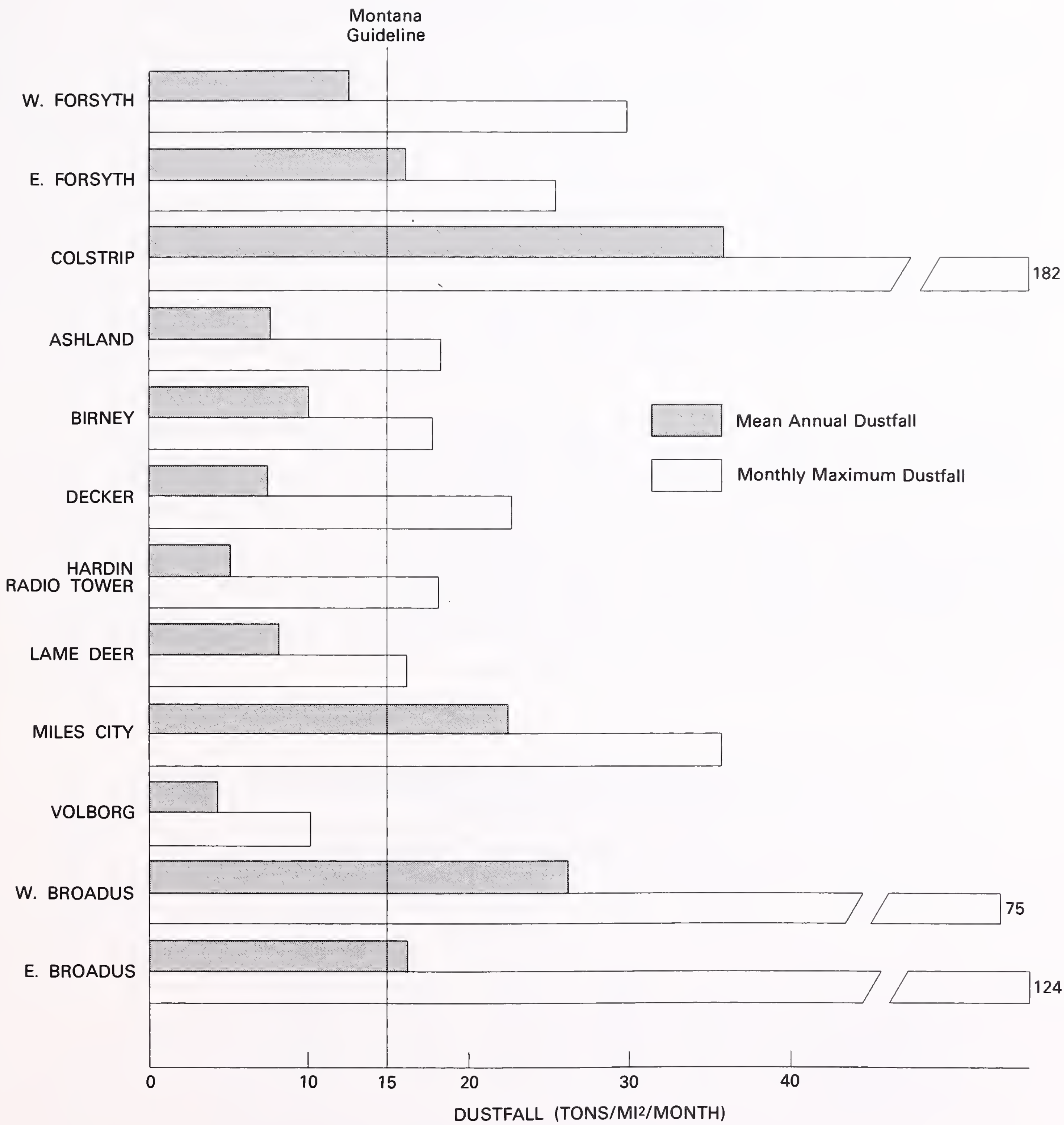


FIGURE II-20.--Annual and monthly maximum dustfall in towns of the northern Powder River basin, 1972-73. Source: Gelhaus, 1976.

TABLE II-11.--1978 emissions from minesite internal combustion engines and blasting (tons/yr)

Mine	CO	NO_x	SO_2	HC	HCN	Aldehydes	Particulates
Western Energy Co.							
Diesel fuel----	91.5	390.0	29.0	39.3	---	9.0	25.4
Gasoline-------	234.8	17.3	0.5	18.5	---	---	1.9
ANFO[1]----------	52.8	47.7	---	---	0.1	---	---
Big Sky mine							
Diesel fuel----	8.6	36.7	2.7	3.7	---	0.8	2.4
Gasoline-------	21.7	1.6	0.1	1.7	---	---	0.2
ANFO	15.7	1.2	---	---	0.04	---	---
Decker Coal Co.							
Diesel fuel----	138.8	591.4	44.0	59.6	---	13.7	38.5
Gasoline-------	282.8	20.8	0.6	22.3	---	---	2.2
ANFO-----------	85.6	71.9	---	---	0.2	---	---
Big Horn mine							
Diesel fuel----	78.6	335.2	25.0	33.8	---	7.8	21.8
Gasoline-------	3.4	0.3	---	0.3	---	---	---
ANFO-----------	27.0	22.7	---	---	0.1	---	---

[1]Ammonium nitrate-fuel oil, an explosive.

TABLE II-12.--Estimated gaseous and particulate emissions based on resident population, 1978

	Pollutants, tons/year				
Town	SO_2	CO	NO_x	HC[1]	Particulates
Colstrip----	192	2,303	466	367	165
Forsyth-----	173	2,708	420	322	148
Hardin------	231	2,775	562	430	198
Hysham------	43	520	105	81	37
Broadus-----	64	767	155	119	55
Sheridan, Wyo.------	7,075	22,834	5,306	4,020	4,824

[1]Hydrocarbons.

4. Emissions from Colstrip Units 1 And 2

a. Sulfur dioxide (SO_2)

Sulfur dioxide (SO_2) is the most abundant pollutant from the powerplants. Total annual SO_2 emissions from units 1 and 2 were about 23,700 tons in 1978 (Montana Department of Natural Resources, 1976).

SO_2 emissions from units 1 and 2 vary primarily with percent sulfur in coal, scrubber efficiency, and power output. Figure II-21 shows the variations in sulfur content, Btu content, and moisture content of Area E coal burned from January 1976 to March 1977. Figure II-22 shows the variations in SO_2 emissions for that period. During that time the mean SO_2 emissions were 0.18 lb/10^6 Btu and 0.16 lb/10^6 Btu for units 1 and 2. This is well within the NSPS of 1.2 lb/10^6 Btu and the Montana standard of 1.00 lb/10^6 Btu.

During plume strikes 2 miles downwind of Colstrip units 1 and 2, mean hourly SO_2 concentrations average about 0.05 ppm (parts per million); at 7.5 and 11.3 miles, about 0.01 ppm.[5] Maximum hourly SO_2 concentrations have been 0.115 ppm at 2 miles and 0.04 ppm at 7.5 miles--within the applicable Federal ambient air quality standards. (See table III-2.) Plume strikes occur at least twice a week in the Colstrip vicinity with no apparent seasonal regularity.[5] The buttes 3 miles north and south of Colstrip tend to be impacted most heavily by the powerplant plumes. Gordon and others (1978) have documented subtle injury to conifers in these areas.

b. Nitrogen oxides (NO_x)

Applicant projections for NO_x emissions are 2,370 lb/hour for units 1 and 2, or about 10,400 tons per year. Figure II-23 shows that while burning Area E coal, NO_x emissions from units 1 and 2 are, for the most part, well within NSPS (table III-4). Statistical analysis for these stack tests reveal that at proper plant operation the upper limits of NO_x emissions could occasionally exceed the NSPS of 0.7 lb/10^6 Btu (EVST Laboratory, 1978).

c. Fluoride (HF)

HF emissions from units 1 and 2 probably range from 0.017 to 0.725 lb/hour (EVST Laboratory, 1978) or 150 to 6,350 lb/year. These estimates are crude: they assume that 0.5 percent of the fluoride in the coal would be emitted as HF (a 3-day stack sample showed less than 1 percent) (O'Toole and others, 1977); and they assume that the Rosebud coal contains 4 to 173 ppm of fluoride (EVST Laboratory, 1978).

---

[5]Weber, Dave, 1979, oral commun., U.S. EPA, January 1979.

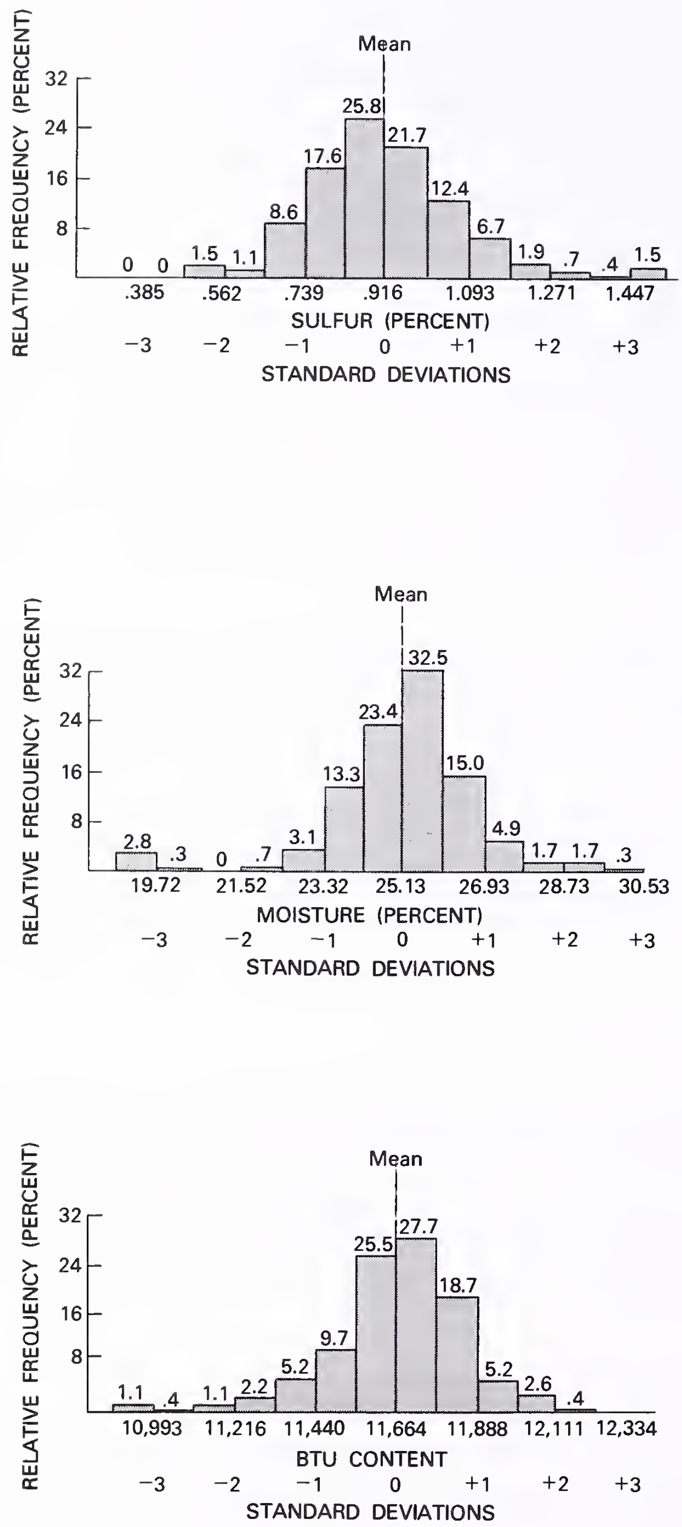


FIGURE II-21.--Sulfur, moisture, and Btu content of coal from Area E of the Rosebud mine. Source EVST Laboratory, 1978.

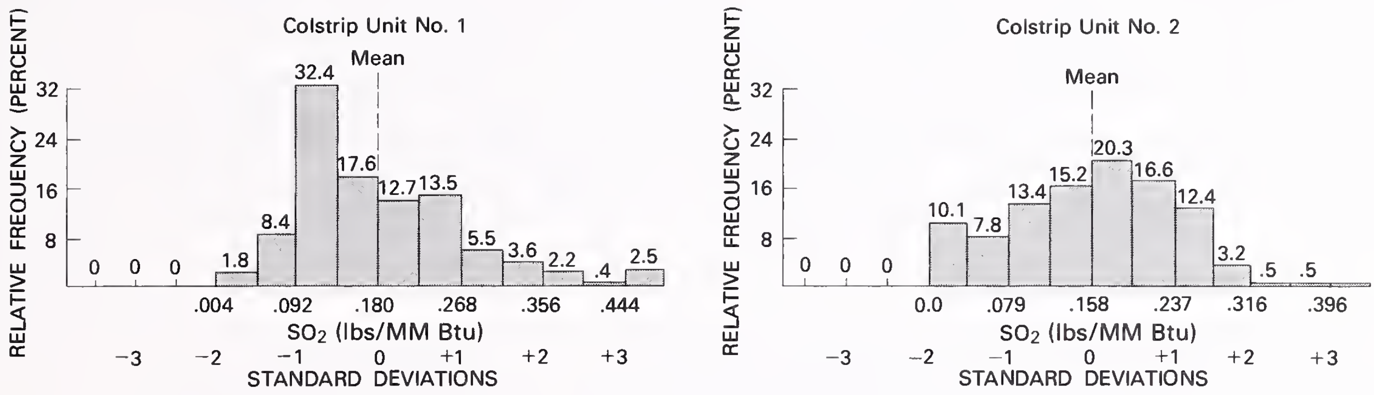


FIGURE II-22.--Sulfur emissions from Colstrip units 1 and 2.
Source: EUST Laboratory, 1978.

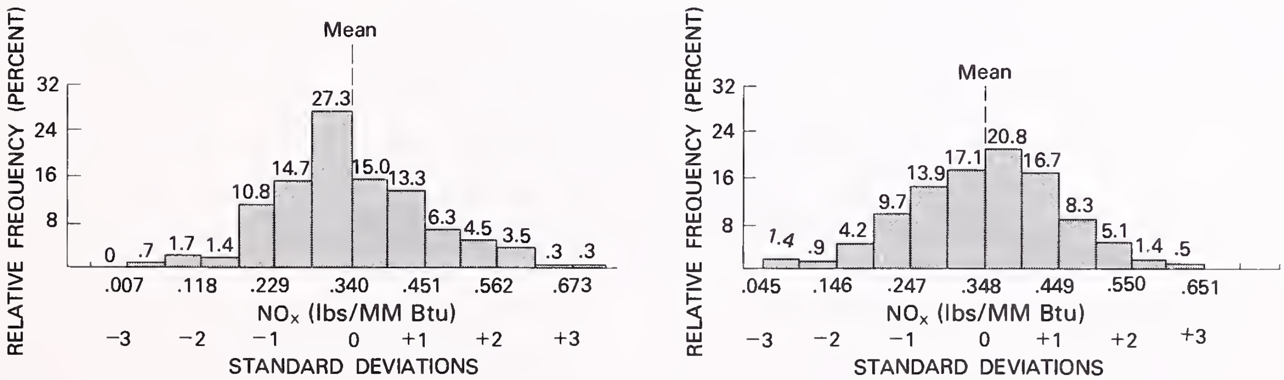


FIGURE II-23.--NO_x emissions from Colstrip units 1 and 2.
Source EVST Laboratory, 1978.

d. Carbon dioxide (CO_2) and carbon monoxide (CO)

Recent stack tests indicate that CO emissions are very low due to the abundance of oxygen during coal combustion (EVST Laboratory, 1978). However, this creates considerable CO_2 emissions. Assuming the CO_2 emission rate from units 1 and 2 is 800 tons/hour and the powerplants run 80 percent of the time, 5.6 million tons of CO_2 are released annually.[6] With the CO_2 emissions from the Corette coal-fired powerplant in Billings, a total of 7.1 million tons of CO_2 leave the study area annually. (See Climate, chapter IV.)

e. Particulates

Total particulates from Colstrip units 1 and 2 probably range from 0.027 to 0.034 lb/10^6 Btu, or about 900 tons/year, assuming a mean ash content of 8 percent. This is well within both the NSPS emission standard (0.1 lb/10^6 Btu) and the Montana emission standard (0.14 lb/10^6 Btu).

Although the particulate removal systems are 99.5 percent efficient, the remaining 0.5 percent is primarily composed of submicrometer particles (Montana Department of Natural Resources and Conservation, 1976). Eighty percent of these stack particulate emissions are less than 0.5 micrometers in diameter (table II-13). These particles can remain airborne for days or weeks and thus be transported up to 600 miles (O'Toole and others, 1977).

TABLE II-13.--Particle size distribution for Colstrip unit 2 sample

[Source: O'Toole and others, 1977]

Particle size (aerodynamic diameter in micrometers)	Percent of total particulate (dry weight basis)
1.1	1
.55	17
.30	10
.30	69

The particle size distribution in the powerplant plume downwind of Colstrip also shows significant increases of 0.03 to 0.2 micrometer and 1.0 to 8.0 micrometer particles over background (fig. II-24). The farther the plume moves from the plant, the greater the concentrations of certain

[6]Keltz, Harry, 1979, oral commun., Air Quality Control Engineer, Department of Health and Environmental Sciences, Air Quality Bureau, January 4, 1979.

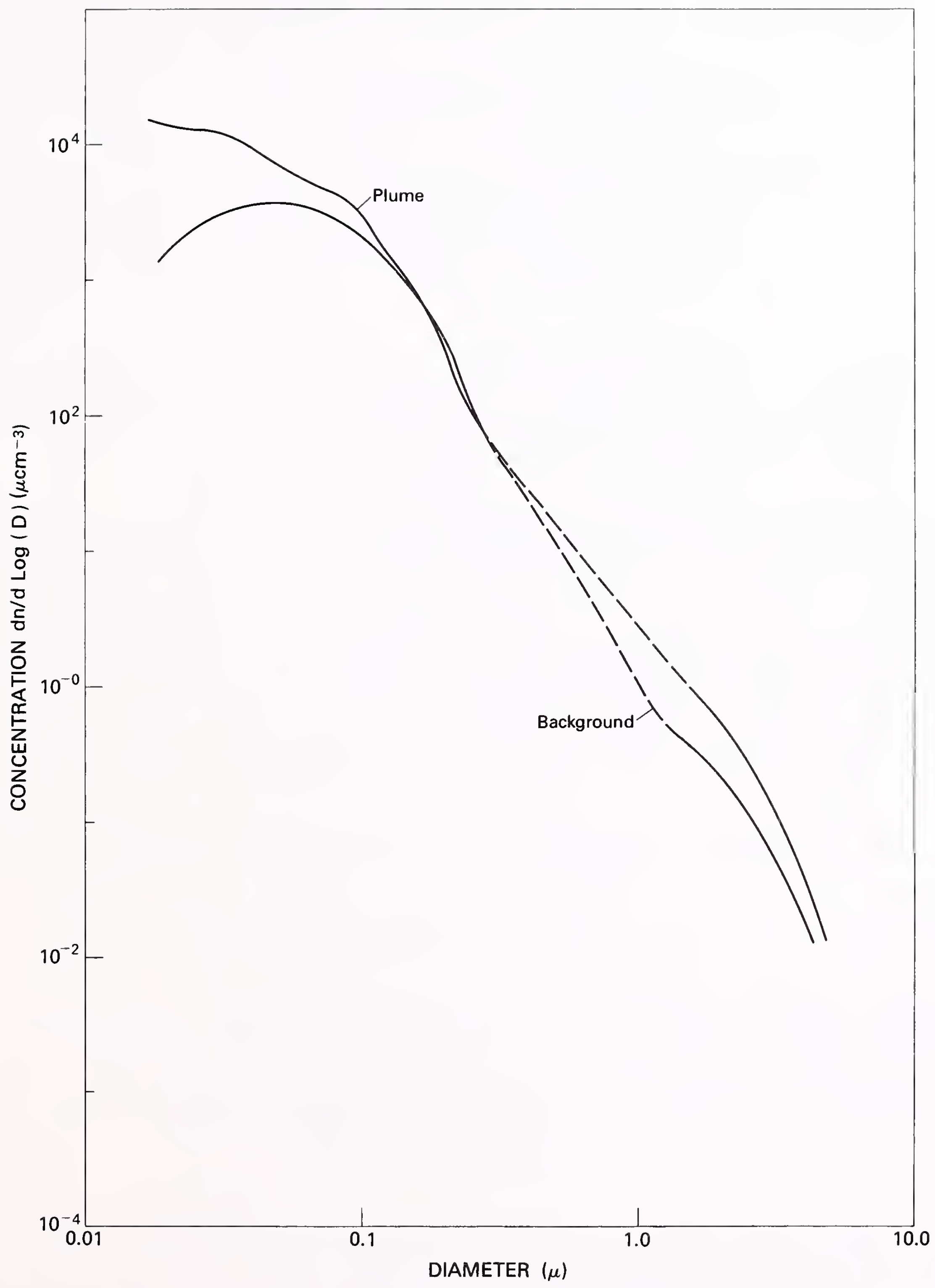


FIGURE II-24.--In-plume and background particle size spectra at Colstrip units 1 and 2, September 3, 1978. Dashes show extrapolated size interval (concentrations too low for accurate measurement). Source: University of Wyoming, 1977.

submicrometer particles. The University of Wyoming team (1977) reported that cloud condensation nuclei (CCN, 0.2-0.4 micrometer) in the plume were increasing between 12 and 15 miles downwind of Colstrip, and at the farthest sample flight (25 miles downwind) CCN concentrations were even higher. CCN concentrations at these distances were 3 to 6 times higher in the powerplant plume than in background air. Particles of this size are effective light scatterers (decreasing visibility) and in sufficient quantity may decrease precipitation frequency. Ice nuclei also have been shown to increase tenfold over background (VanValin and Pueschel, 1977), 8 miles from the plants. These particles may increase snow and ice-phase rain. (See Climate, chapter IV.) The net effect on precipitation is unknown.

Fine particulates from Colstrip units 1 and 2 may catalyze the formation of sulfuric acid from SO_2 or nitric acid from NO_2, accelerating the formation of sulfates and nitrates and promoting acid rain (Perera and Karim Ahmed, 1978). (See Climate, chapter IV.)

Rain near Colstrip may have become slightly more acid after generating units 1 and 2 were built; this may be due to local washout of sulfur and nitrogen oxides, and possibly chlorine- and fluorine-containing compounds from the plume. It could also be due to long-range rainout from pollution sources hundreds of miles upwind. In 1973, mean pH of rain near Colstrip was 6.5, and ranged from 5.2 to 8.7 (Montana Department of Natural Resources and Conservation, 1976); the equilibrium pH of rain in the U.S. is 5.7 (Li and Landsberg, 1978). In 1977, after units 1 and 2 were in operation, mean pH was 5.2 and ranged from 4.0 to 7.3 (EVST Laboratory, 1978). The 1978 data illustrate that acid rain is present, regardless of source.

Submicrometer particles emitted from Colstrip units 1 and 2 are enriched in arsenic, selenium, antimony, mercury, fluorine, lead, vanadium, copper, and zinc (Crecelius and others, 1977). The increased surface area of small particles promotes adsorption of volatized trace metals in the stack gas. Table II-14 shows predicted and observed trace metal emissions from Colstrip units 1 and 2. The observed emissions are conservative since, during the collection of the sample, a significant amount of small-diameter particles may pass undetected through filter paper (EVST Laboratory, 1978). Although these figures vary considerably with the trace metal concentrations in coal, the observed emissions suggest that fine particulates may enhance the long-range dispersal of potentially toxic trace elements to the environment.

Honeybees and portions of ponderosa pine needles have shown statistically significant increases in fluorine since the start-up of Colstrip units 1 and 2 (Gordon and others, 1978; Bromenshenk, 1978). The extent to which other vegetation, soils, and foraging wildlife have begun to scavenge damaging or toxic levels of these trace elements is not known.

TABLE II-14.--Predicted and observed selected trace elements emissions from Colstrip units 1 and 2

[Source: Department of Natural Resources, 1976; Crecelius and others, 1977]

Trace element	Predicted (tons/year)	Observed March 15-17, 1976 (tons/year)
Arsenic-------	1.32	1.66
Fluorine------	9.04	16.02
Copper--------	1.01	---
Mercury-------	0.45	2.01
Selenium------	0.28	1.56
Antimony------	0.24	0.19
Vanadium------	0.80	---
Zinc----------	13.21	---

5. Air Quality Modeling, Colstrip Area, 1978

The air quality model used to predict dustfall and total suspended particulate (TSP) levels was provided by the University of Montana. A full description of the computer model is available from the Montana Department of State Lands, Capitol Station, Helena, Montana 59601. The model gives a best estimate of particulate concentrations and dustfall based on available data. Because of the uncertainty in fugitive dust emission factors used in the model, the actual concentrations and rates may be somewhat larger or smaller than predicted.

a. Total suspended particulates

Because current measurements of concentrations are incomplete, particulate emissions from both the Rosebud and the Big Sky mines were modeled to estimate 1978 TSP concentrations (fig. II-25). TSP concentrations of up to 5 $\mu g/m^3$ above the background 20 $\mu g/m^3$ were modeled from 10 to 12 miles downwind of the strip mines. Approximately 250 square miles could have recorded increases in TSP due to mining in 1978.

Most of the fugitive dust travels eastward, carried by the prevailing winds. (See figure II-14.) Predicted violations of the annual geometric mean and the maximum 24-hour average for TSP are generally confined to the mining areas, near major haul roads and coal handling facilities (fig. II-25). TSP readings are unusually high in the mobile home court north of the powerplant's coal handling facilities.

The modeled 1978 annual geometric mean concentration for TSP at Colstrip was about 50 $\mu g/m^3$. In 1977, the observed mean concentration was 81 $\mu g/m^3$, and the observed 24-hour maximum concentration was 306

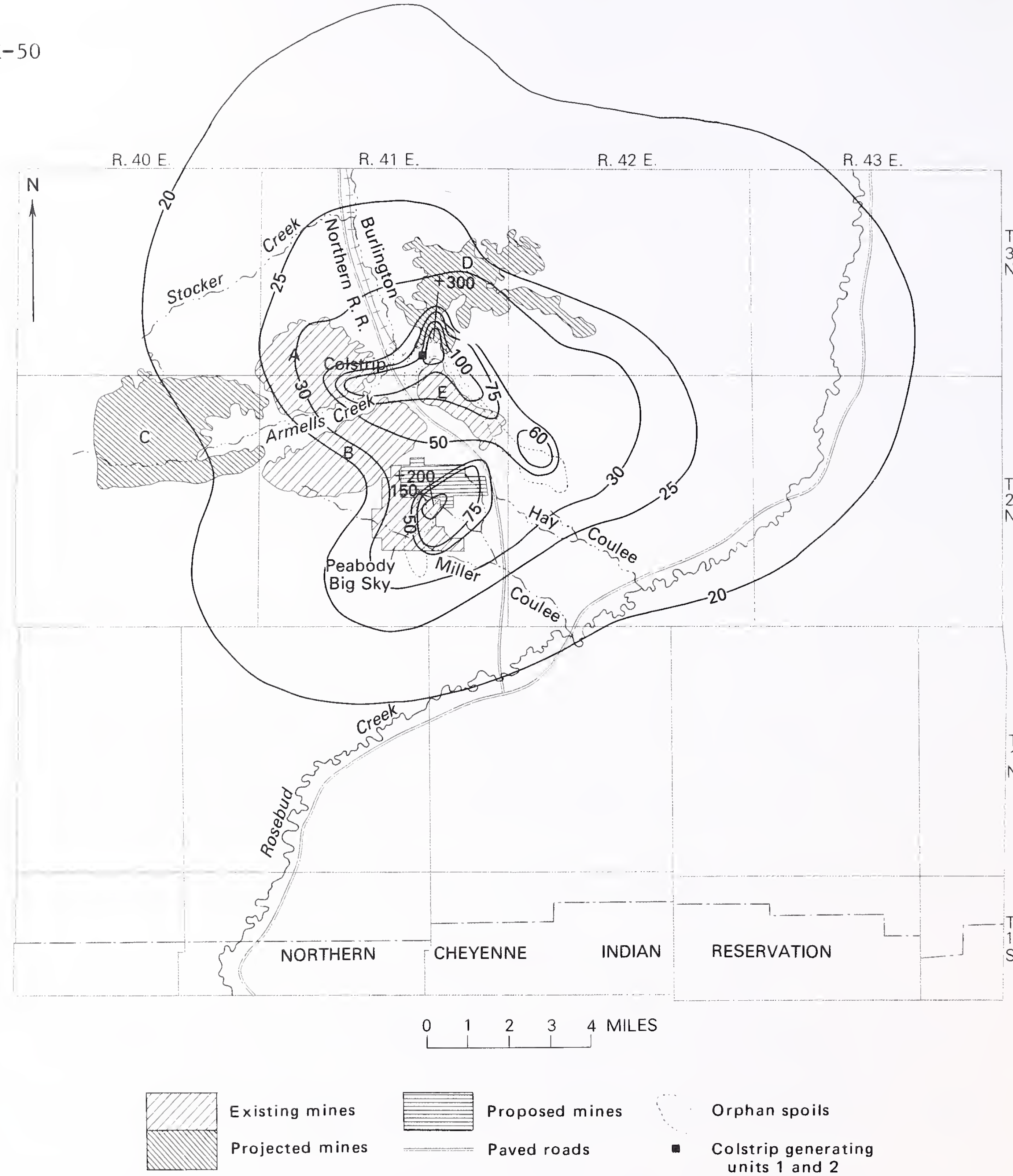


FIGURE II-25.--Annual geometric mean TSP ($\mu g/m^3$) during 1978 in the Colstrip area. Background concentration of 20 $\mu g/m^3$ is included.

$\mu g/m^3$; both concentrations violated the NAAQS for TSP. The model predicts a 24-hour maximum of 124 $\mu g/m^3$ during the summer. Since the model is unable to account for dry summer weather, violations of the 24-hour TSP standard are difficult to predict.

The Big Sky mine, at the present coal production rate of 2.3×10^6 tons per year, adds an average annual concentration of 1 $\mu g/m^3$ of TSP to the town of Colstrip (fig. II-26).

b. Dustfall

Dustfall tends to follow the same geographic patterns as TSP (fig. II-27). Generally, predicted violations of the 3-month dustfall standard are confined to the immediate vicinity of the mine. In 1978, approximately 200 square miles were affected by dust from the mines (fig. II-27).

c. Model deficiency, fine particulates

The model does not estimate the amount of fine particulates from the mines, because it is calibrated after real TSP data at Colstrip, and only reflects these crude measurements of the ambient particulate problem. Fine particulates weigh too little in relation to the larger particles collected to be recorded as significant portions of a dust sample. Thus, the model assumes that fugitive dust from strip mines consists almost entirely of large-diameter particles which settle out close to the source.

A portion of the particle size dustribution of coal and overburden at Colstrip naturally contains particles of 5 micrometers and below; 1 percent of the coal may be below this size (Paulson and others, 1976; Boscak and Tandon, 1974). Clay-sized particles (0.06 to 4.0 micrometers) from area B overburden average about 26 percent (Dollhopf, Hall, and others, 1978). The average clay content of soils and overburden at Big Sky is approximately 20 percent (Peabody Coal Co., 1977); however, these clay particles are predominantly kaolinite and tend to adhere to each other, reducing their erosion potential and residence time in the air.

Long-range aircraft samples of the fugitive dust plume from Colstrip show that, although the concentrations of small particles are much higher than background (and usually much higher than those from Colstrip units 1 and 2), the size distribution is the same (fig. II-28, University of Wyoming, 1977). This evidence, while in agreement with the LASA (1978) study, further suggests that during the warmer months of the year, fine particulates originating from the strip mines may rise several hundred feet and travel several miles downwind.

d. Trace elements in fugitive dust

Some trace elements in coal dust and overburden from the Colstrip-area mines occur in higher concentrations than in topsoils of the region. (See Geology.) These trace elements settle out in patterns similar to the dustfall patterns shown in fig. II-27.

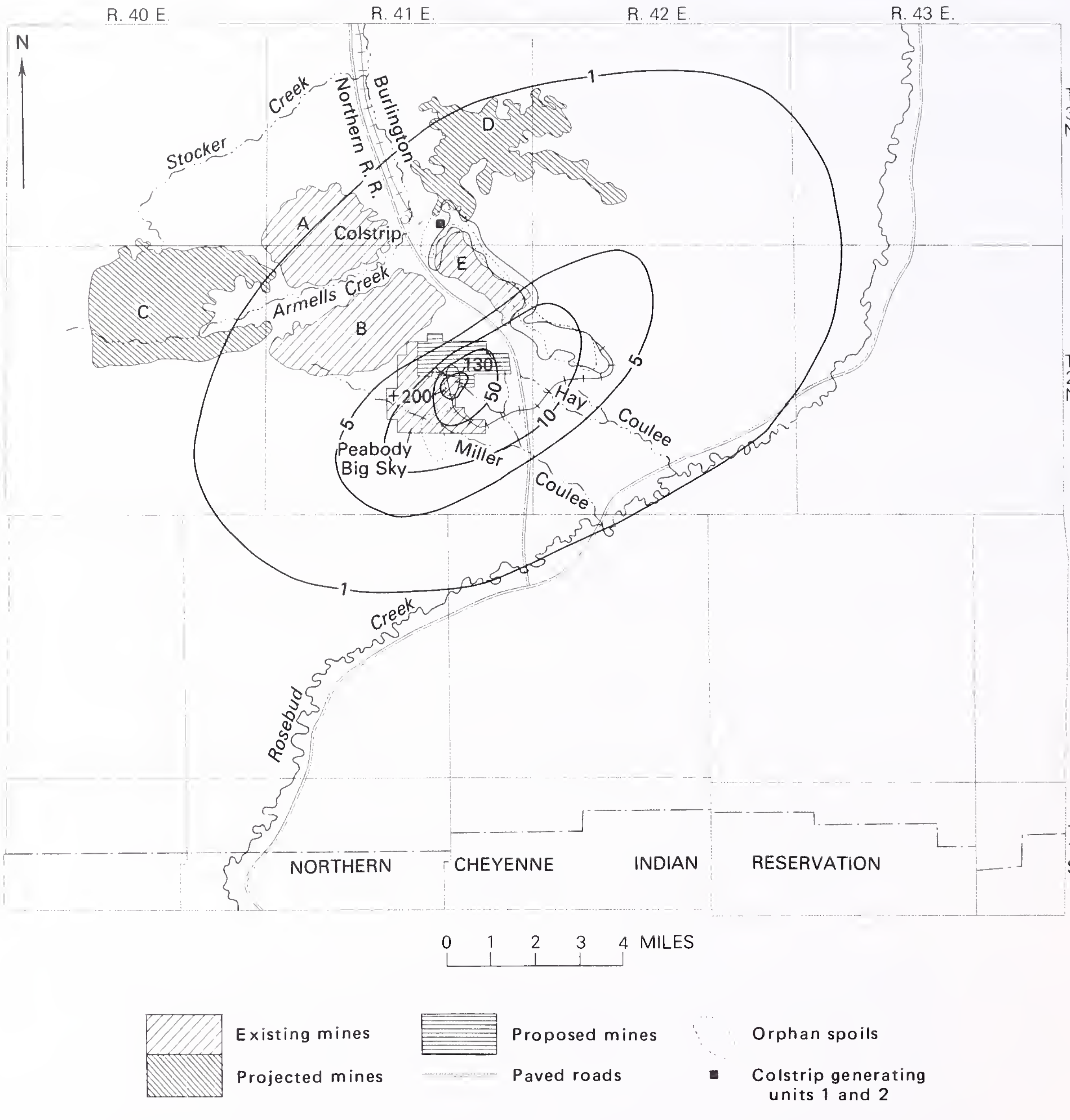


FIGURE II-26.--Annual geometric mean TSP ($\mu g/m^3$) during 1978 from the Big Sky mine. Background is not plotted.

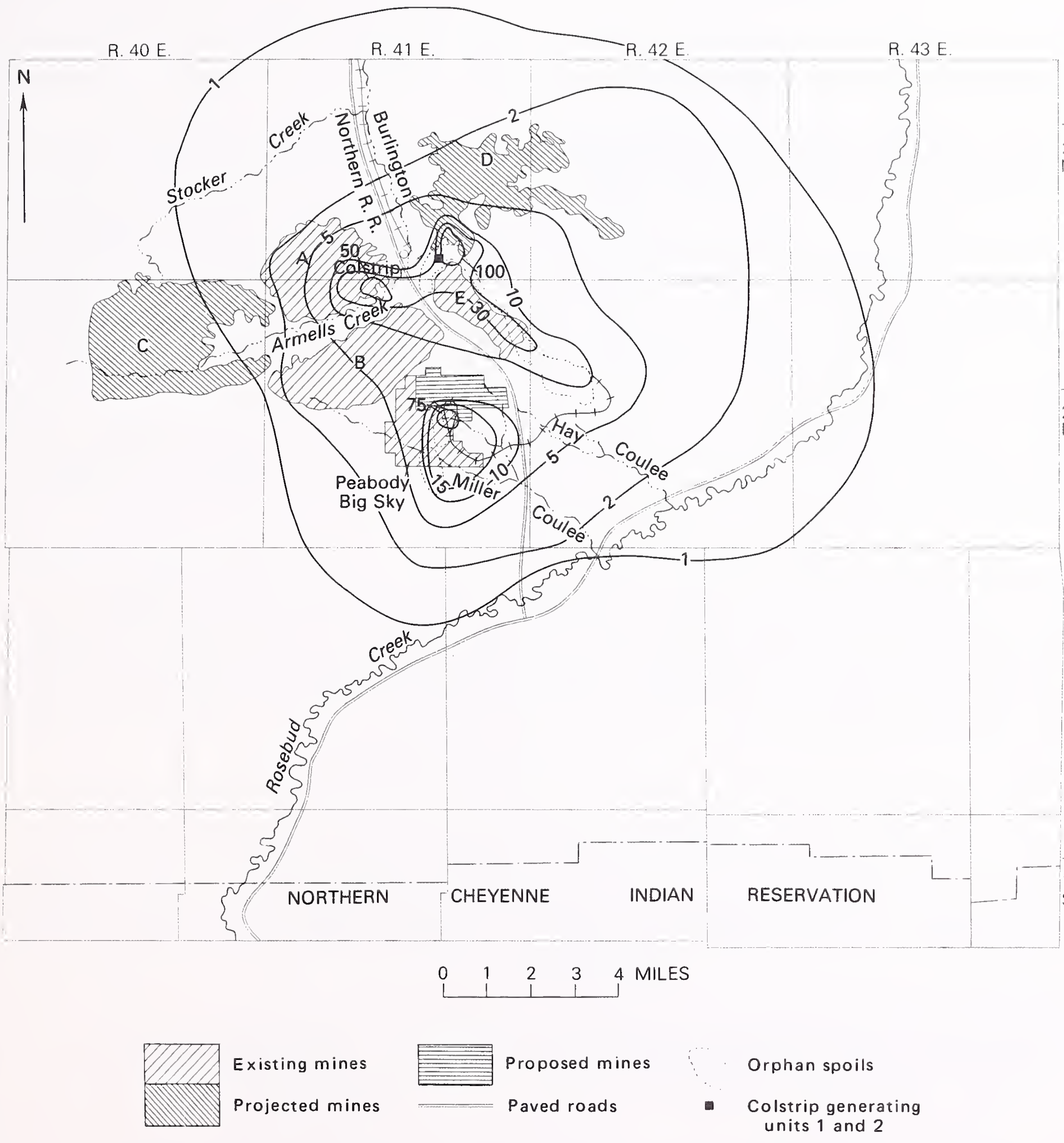


FIGURE II-27.--Annual mean monthly dustfall (tons/mile^2/month) during 1978 in the Colstrip area. Background is not plotted.

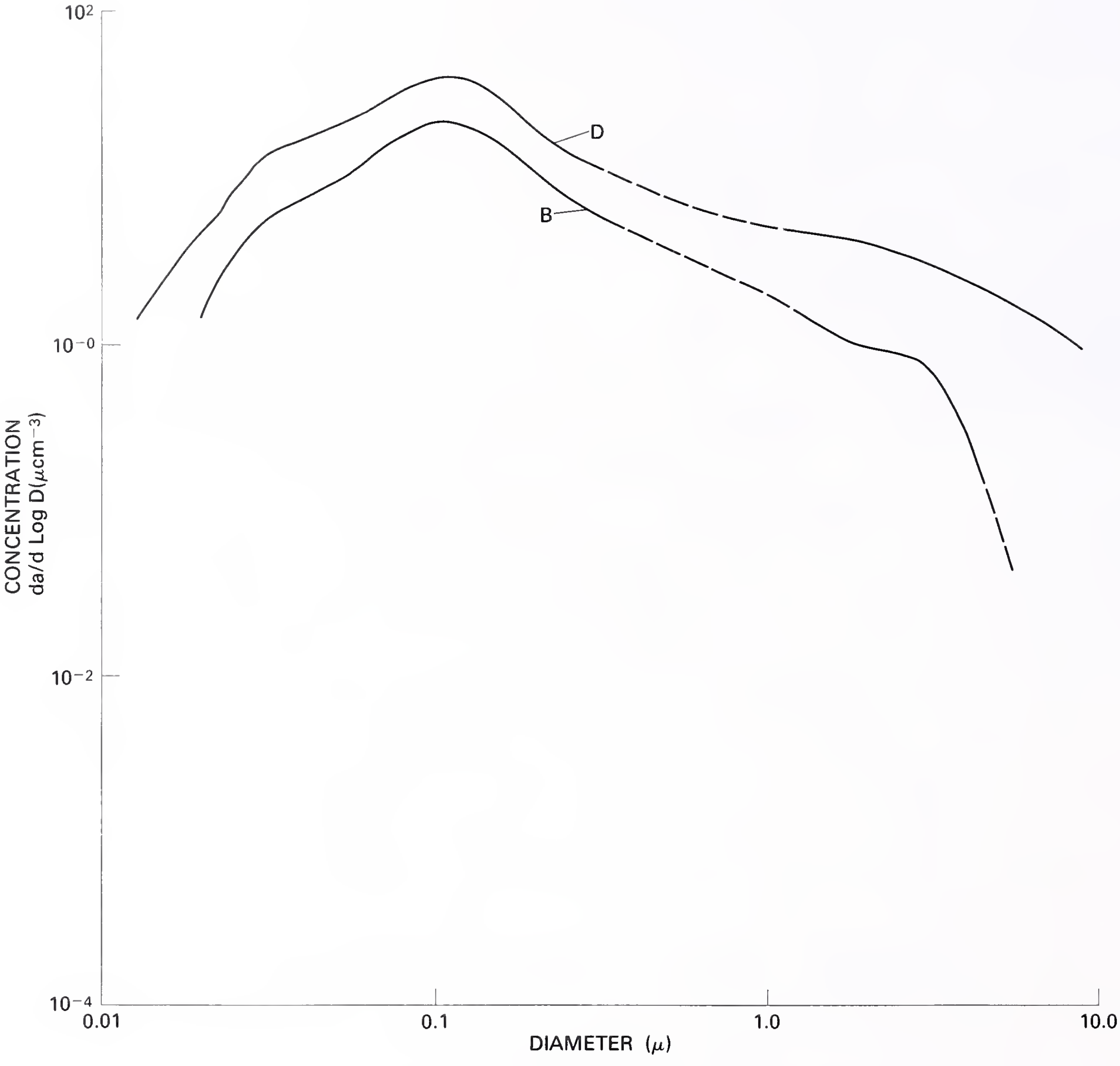


FIGURE II-28.--Particle size distribution of a fugitive dust sample from the Rosebud mine (D) and background on September 1, 1976 (B). Source: University of Wyoming, 1977.

6. Air Quality Modeling, Decker Area

a. Total suspended particulate concentrations

The model predicts TSP concentrations above background extending about 25 miles downwind of the Decker strip mine area (fig. II-29). Mean annual concentrations of about 5 $\mu g/m^3$ above background extend 10 miles east of the Decker mines, whereas such increases are confined to the immediate vicinity of the Ash Creek and Big Horn mines. The total area affected is approximately 500 square miles. Predicted violations of the annual geometric mean for TSP are confined to the permit area boundaries or the immediate vicinity of the mine. Although the Decker area dust model is much too crude to predict 24-hour maximum TSP values, actual violations of this standard occurred in 1977 (fig. II-30).

The Pearl and the Spring Creek minesites, upwind of the Decker area, record very low TSP concentrations which indicate clean, undisturbed environments (fig. II-30).

b. Dustfall

Dustfall rates ranging from a maximum of more than 25 tons/mi^2/month to a minimum of 15 tons/mi^2/month occur over an area of roughly 300 square miles (fig. II-31). This area overlaps the proposed sites for both the Pearl and Spring Creek mines. Background dustfall measurements made upwind of the proposed Pearl site average 6 tons/mi^2/month.

c. Trace elements in fugitive dust

Some trace elements in coal dust and overburden from the Decker West and East mines occur in higher concentrations than in topsoils of the region. (See Geology.) Fugitive dust particles from the Decker mines may transport relatively higher concentrations of certain trace elements than most strip mines of the area, because of the very high cation exchange capacity of the overburden.

E. SOILS

1. General Description

Soils in the region vary considerably in depth and profile development, reflecting differences in mean annual precipitation (12-19 inches/yr), underlying bedrock, geomorphic stability, and, to a limited extent, vegetation. Most of the soils in the region are poorly developed, and most of their character is inherited from geologic parent materials due to very slow rates of soil formation. Most of the soils which may ultimately be mined were formed under shrub and grassland vegetation and are calcareous and relatively low in organic matter. Locally, where ponderosa pine dominates the plant communities at higher elevations, soils are slightly acid and comparatively high in organic matter. These soils

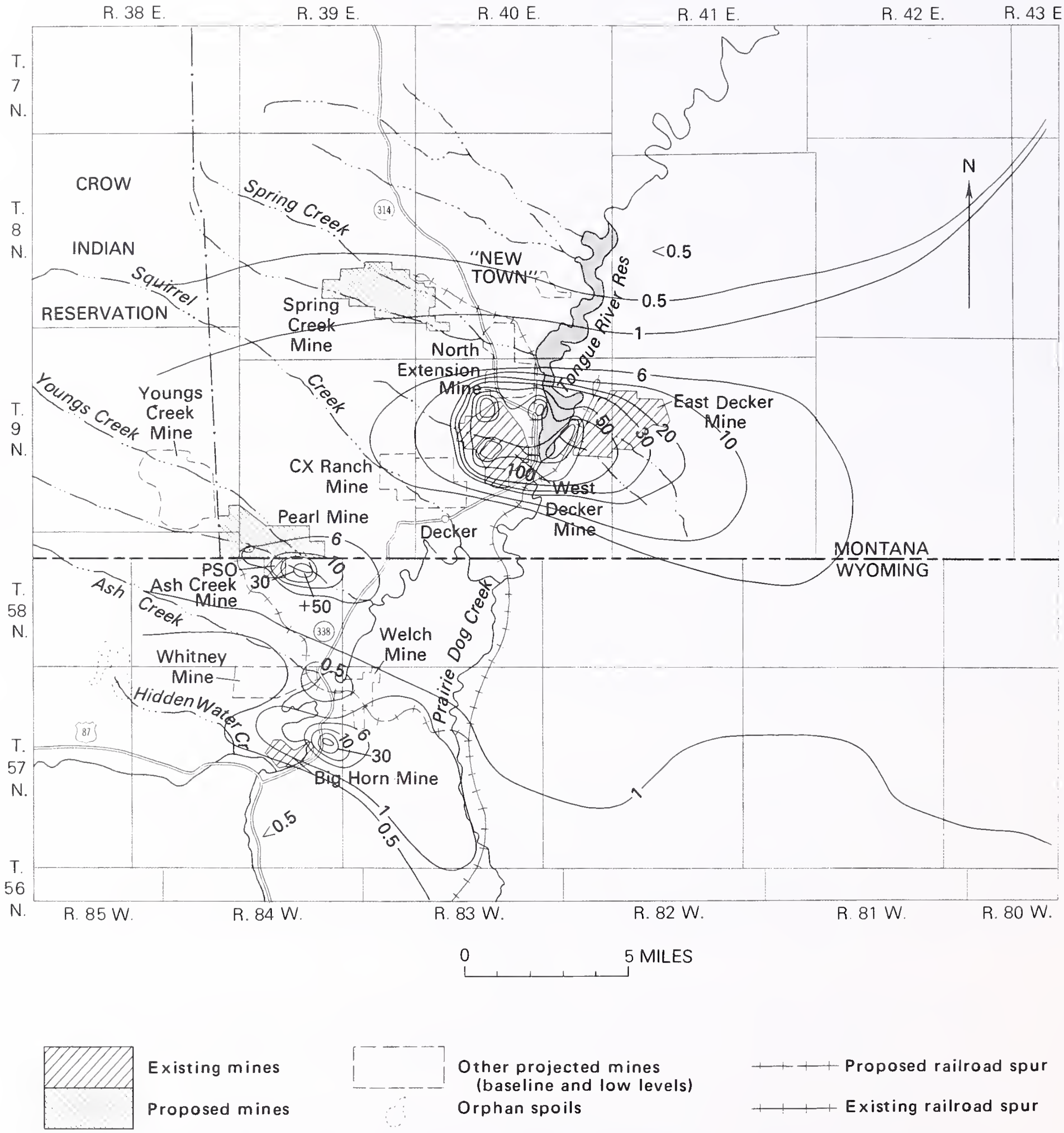


FIGURE II-29.--Annual geometric mean TSP ($\mu g/m^3$) in the Decker area during 1978. Background is not plotted.

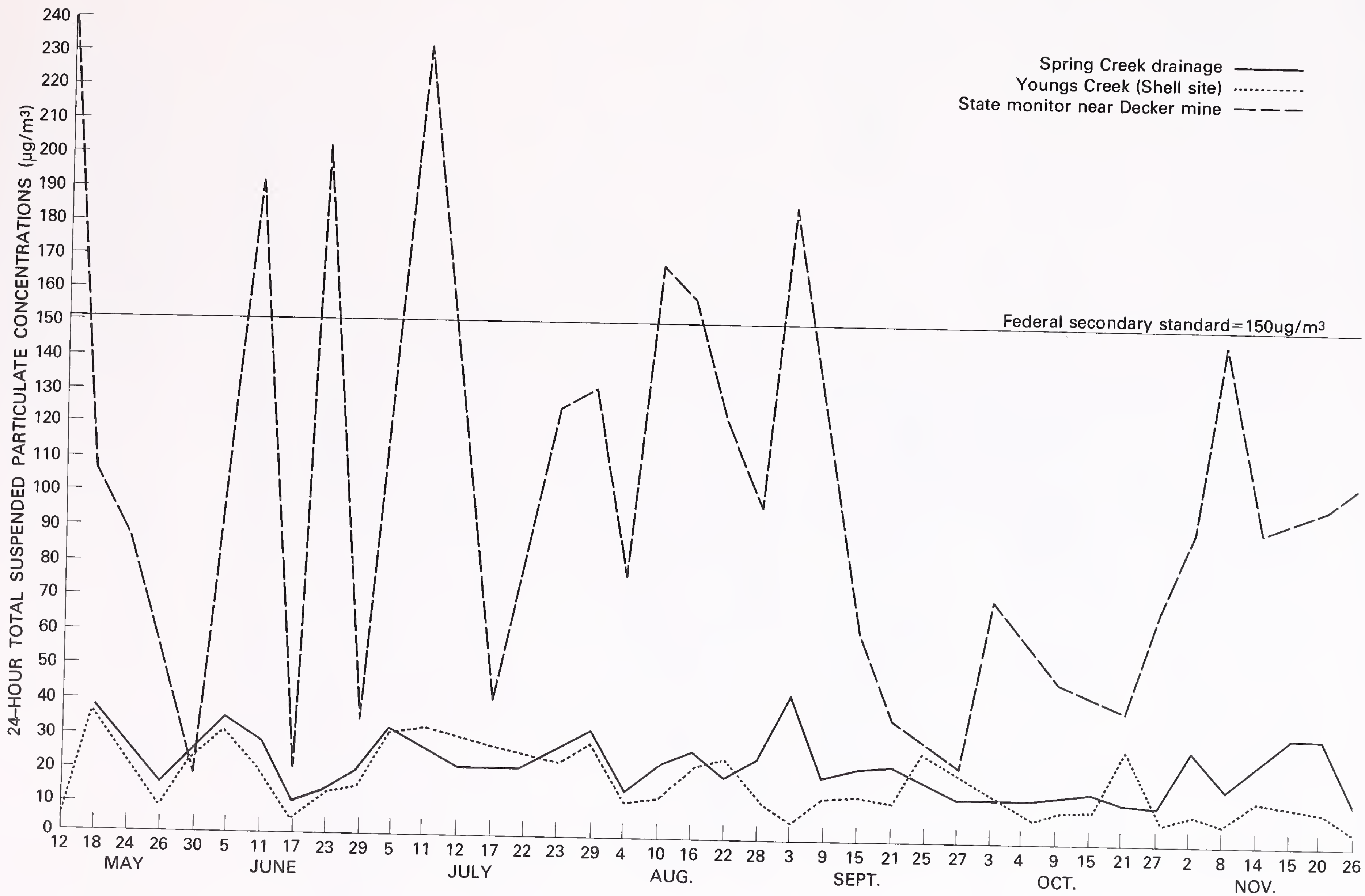


FIGURE II-30.--Comparison of TSP recordings at Decker, Spring Creek, and Youngs Creek, 1976.

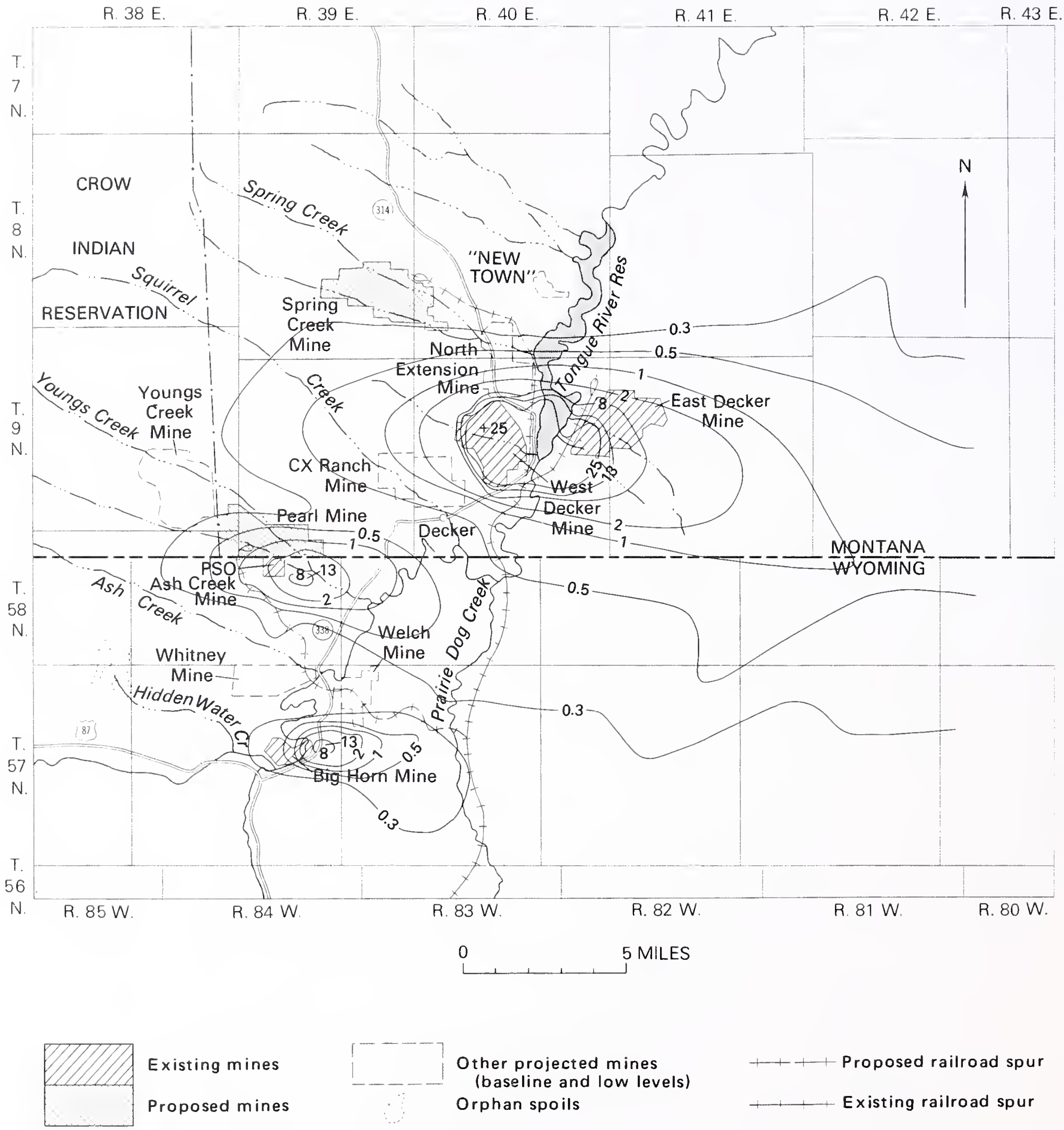


FIGURE II-31.--Annual mean monthly dustfall (tons/mi^2/month) in the Decker area during 1978. Background is not included.

occupy an insignificant part of the region, mostly on the Custer National Forest, which is excluded from coal mining.

In Big Horn and Powder River Counties, soils have been mapped by the Soil Conservation Service (USDA, 1971, 1978). Rosebud County is now being mapped but will not be completed for several years. A soils map of Montana is being prepared.[7] The three proposed minesites have been mapped in detail. Soils that have been mapped suggest the following generalizations for the study area and for the proposed minesites. (See table II-15.)

About 65 percent of the soils of the study area are Entisols, which include both upland and alluvial soils. The Entisols have very little profile development, because the steeper upland soils tend to erode and the alluvial soils tend to be buried before well-developed profiles can form.

About 15 percent of the soils are Mollisols, which have well developed "A" or surface horizons. Most of these Mollisols (mainly the widespread Ringling series) have little or no development below their "A" horizons; a few have well developed (argillic) "B" horizons (the Fergus Series) or moderately well developed (cambic) B horizons (the Spearman Series).

About 20 percent of the soils are Aridisols, which have moderately well-developed A horizons and well-developed argillic or cambic B horizons. Those Aridisols with argillic horizons probably formed mainly during the late Pleistocene, under wetter and/or cooler conditions (U.S. Department of Agriculture, 1975). If disturbed, these soils would not regain their original structure and profile under the current climate. Many of these soils have accumulated soluble sodium, magnesium, and calcium salts in the "B" horizons during the recent past (8,000 to 10,000 years). This is a result of limited water flow through the soil profile after most of the development occurred.

Since soil profiles are typically not well developed in the region, the soils closely reflect underlying bedrock characteristics. Figures II-2, II-3, and II-32 illustrate the distribution of geologic parent materials and the relation between these materials, topographic position, and soils. Soils formed on the Fort Union Formation, which range from claystone to sandstone, are clayey to sandy. Fine loamy textures predominate, with major exceptions, such as some of the areas in and around Colstrip where unusually sandy textures are common. Clay mineralogy varies dramatically, from smectites to kaolinite, with the result that soils respond very differently to handling and reclamation efforts.

---

[7]Simonson, G. H., Brownfield, S. H., Rodgers, J. W., Richardson, R. E., and Nielsen, G. A., 1979, General Soil Map of Montana: Bozeman, Montana, USDA-SCS, Montana Agricultural Experiment Station, Montana State University (in press).

TABLE II-15.--Representative soil series of the northern Powder River region

[Source: U.S. Department of Agriculture, 1971; 1978]

Soil	Classification	Profile development	Rooting depth[1] (inches)	Approximate mean precipitation (inches)	Topsoil suitability
Entisols:					
Cabba	Typic Ustorthent Loamy, mixed, calcareous, frigid, shallow	A/C	16	15-19	Fair.
Haverson	Ustic Torrifluvent Fine-loamy, mixed, calcareous, mesic	A/C	60+	12-14	Good.
Midway	Ustic Torriorthents Clayey, montmorillonitic, calcareous, mesic, shallow	A/C	14	12-14	Poor.
Thedalund	Ustic Torriorthents Fine-loamy, mixed (calcareous), mesic	A/C	28	12-14	Fair.
Tullock	Ustic Torripsamment Mixed, mesic	A/C	40	13-14	Poor.
Mollisols:					
Farnuf	Typic Argiborolls Fine-loamy, mixed	A/Bca/Cca	60+	14-17	Good to fair.
Ringling	Lithic Haploboroll Loamy-skeletal, mixed	A/AC/C	16	15-19	Poor.
Spearman	Aridic Haplustoll Fine-loamy, mixed, mesic	A/B/C	25	12-14	Fair.
Aridisols:					
Heldt	Ustertic Camborthids Fine, montmorillonitic, mesic	A/B/C	60+	12-14	Fair.
McRae	Ustollic Camborthids Fine-loamy, mixed, mesic	A/B/Cca	60+	12-14	Good to poor.
Thurlow	Ustollic Haplargid Fine, montmorillonitic, mesic	A/Bt/Cca	60+	10-15	Fair.

[1]Rooting depth represents a maximum salvage depth. Typically, salt accumulations in the soil profile reduce potential salvage where mean precipitation is less than 14 to 15 inches. Rock content may also reduce salvage depth.

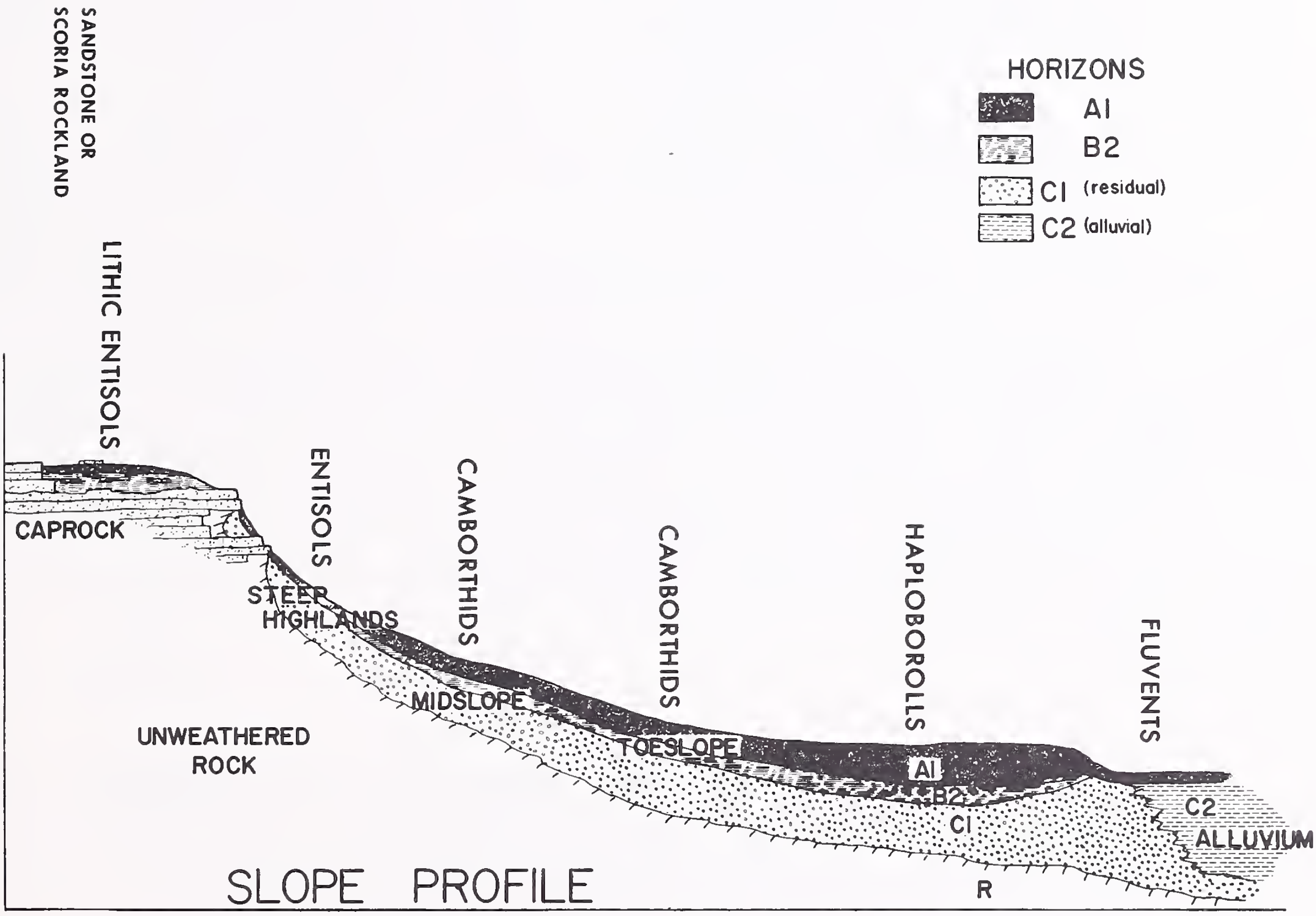


FIGURE II-32.--Representative soils profile in the northern Powder River basin. After Shafer and others, 1978.

Soils formed on resistant sandstone and clinker beds are frequently shallow and rocky, although intensive surveys required for mining permit applications have revealed local inclusions of deep and moderately deep loamy soils; it is not known how often these inclusions occur in the region. Soils developed in clinker have very high permeability and low water-holding capacity. Soils formed on steeply sloping shales are frequently thin to absent. Shales are impermeable and often have high salt content, discouraging plant growth. Such barren outcrops occupy less than 1 percent of the study area, but may be locally important, as they are at the Spring Creek minesite.

Approximately 25 percent of the soils within the region have severe to very severe limitations on cultivation (capability class III and IV). Most of the remaining 75 percent are suited primarily for grazing (class VI and VII), and most soils are used for grazing. Past attempts at dryland farming at the proposed mines were abandoned in favor of grazing. Small areas in river valleys (figs. II-2 and II-3) are suitable for irrigation, placing them in class II or III (Klingebiel and Montgomery, 1961).

Maximum herbage production ranges from 500 to approximately 1,800 pounds per acre with few exceptions. This is the lower range normally found in temperate grasslands. Water is the usual factor limiting plant growth in the region.

2. Reclamation Potential

Conditions at the proposed Big Sky mine expansion are more conducive to successful reclamation than at the other two minesites. The chemical and physical characteristics of the soils and overburden pose few significant problems. Past problems at the existing Big Sky mine have been related to drought and nutrient-poor, sandy soils. Better selection of "topsoil" materials and application of fertilizers have reduced these problems on more recent reclamation surfaces. Salvageable "topsoil" depths in the area proposed for mining average 50 inches--more than adequate to allow selection of the most favorable materials. Precipitation at the minesite averages about 15 inches per year, comparatively high for the region.

Conditions at the Pearl minesite are somewhat less favorable. Precipitation is about 12 inches per year, and both soil and overburden are relatively high in clay, probably dominated by smectite and illite,[8] which readily shrink and swell. Some overburden in the eastern part of the southwest pit contains soluble salts, which could adversely affect small areas of the reclamation surface.

The proposed Spring Creek mine has the least favorable conditions for reclamation. Soils are moderately heavy, generally clay loam to

---

[8]M. Klages, 1975, letter to Peter Kiewit Mining Company regarding clay minerals in overburden, May 27, 1975.

silty clay loam in texture, as is the bulk of the overburden. Soils and overburden are dominated by smectite and illite. Salt accumulations are very common in the deeper soils, which become excessively saline at about 32 inches below the surface. Approximately 50 percent of the overburden is sodic, which poses potentially severe reclamation problems.

Mined land reclamation in the study area was not required until 1973. Before that time, spoils were usually abandoned, although some areas were partially leveled. "Topsoiling" was not practiced, and resulting vegetative productivity ranges from zero (Rahn, 1976) to 2,200 pounds per acre (William Schafer, oral commun.). Plant communities are volunteer and almost always comprise low-quality forage, dominated by weedy species.

Reclamation at mines in the study area represents five growing seasons at most, so success of reclamation has not yet been legally assessed, and won't be before 1983. (See chapter III.) Early reclamation efforts have met with variable initial success, ranging from impressively poor to impressively good. Both extremes are exemplified at the Rosebud mine in Colstrip. Early success and failures have initiated a body of knowledge necessary for realizing the potential for revegetating mined lands.

F. VEGETATION

Vegetation in the study area is typical of the western extension of the northern Great Plains. There is little difference in vegetation patterns between the northern and southern parts of the area. The distribution of vegetation is controlled mostly by the scarcity of precipitation, to some extent by soils, aspect, and land use, and to a minor extent by elevation.

Figure II-33 shows the location of eight vegetative rangeland types (Payne, 1973), in the study area. The following discussion groups three of Payne's categories into one, native grass, and uses substitute names which better describe the composition of each type. Table II-16 correlates the classification used in this discussion with the system used in fig. II-33 and shows acreages of each type. Inventories of vegetation used in the site-specific EIS's are more detailed than the regional inventory. Table II-17 lists common species for each type.

1. Ponderosa Pine-Grass

This type is distinguished by ponderosa pine distributed in patches, intermixed with extensive patches of grassland. The soils range from rocky and stony to loams and alluvium. Topsoils are generally grayish brown and support a wide variety of forage species.

There is a strong association between this type and generally shallow soils underlain by sandstone or shale bedrock. Trees are most often immediately above bedrock or at outcroppings on slopes, where ground water

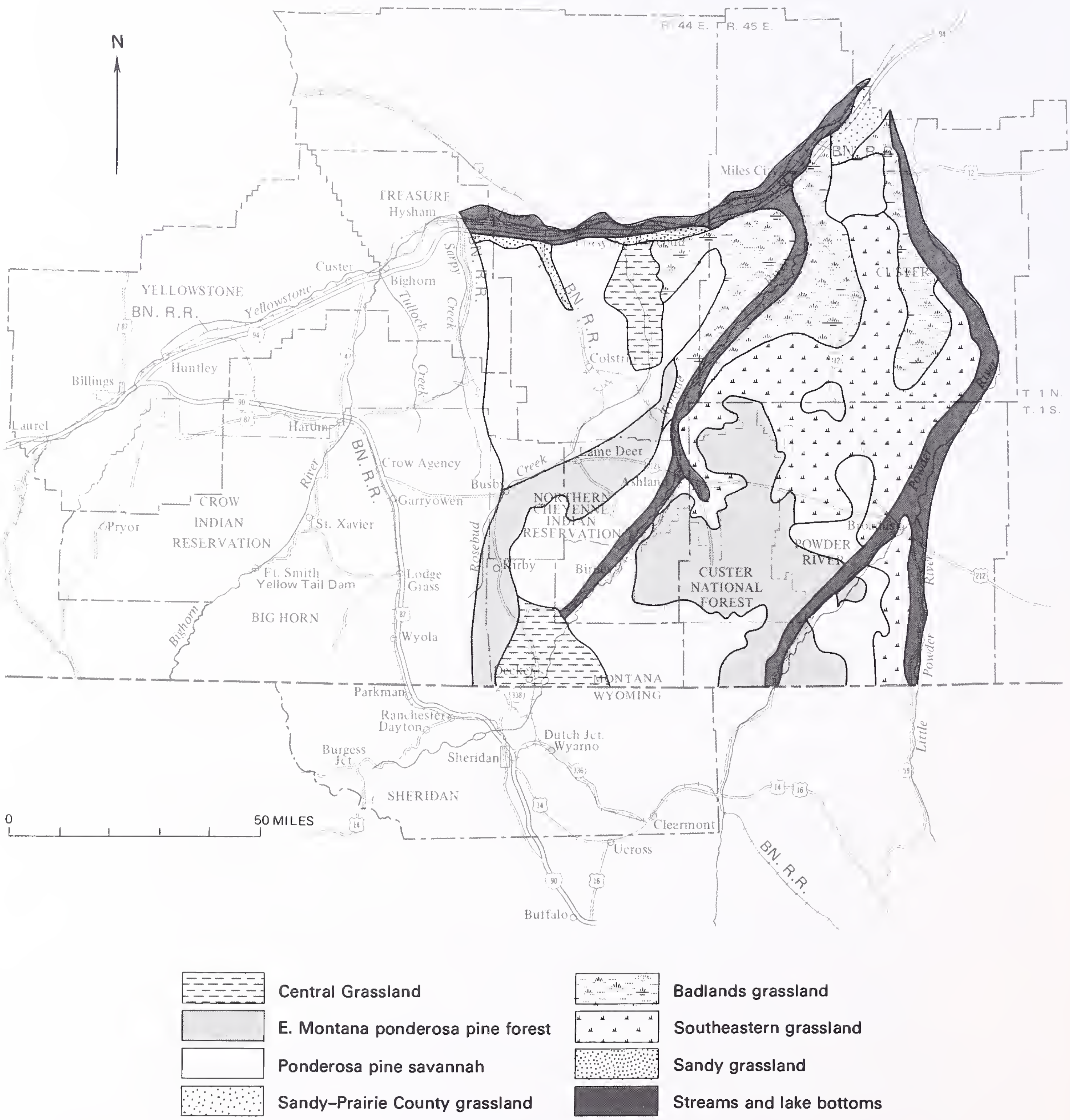


FIGURE II-33.--Vegetative rangeland types in the designated region.

tends to be concentrated along the rock and shale layers. The "islands" of trees provide valuable edge effects for big game species, summer shade for livestock, and pleasant scenery.

There are 14 existing or projected mines entirely or partly within this broad vegetative type. The proposed Big Sky mine expansion would also be partly within this type.

TABLE II-16.--General growth forms and vegetative types in northern Powder River basin study area

Growth form	Vegetation type	Acreage (x 1,000)	Percent
Savannah	Ponderosa pine-grass (Ponderosa pine Savannah)	1,642	34
Scrub	Sagebrush-grass badlands	833	17
	Big sagebrush-grass (Central grassland)	277	6
Grassland	Native grass (Southeastern grassland) (Sandy grassland-Prairie County grassland) (Sandy grassland)	990	21
Forest	Ponderosa pine (Eastern Montana ponderosa pine forest)	830	17
Woody	Riparian (Undifferentiated stream and lake bottoms)	256	5
Total		4,828	100

2. Sagebrush-Grass Badlands

Rough, hilly and broken topography with shadscale saltbrush and greasewood on many of the hilly slopes all distinguish this type. The soils are generally poorly developed, with heavy, shaley clays in drainages and some gravelly soils on the slopes. Most of the threadleaf sedge and needle-and-thread is found on the latter soils, while western wheatgrass is found along the bottomland clays. Buffalograss occurs only along the flat-bottomed drainages.

"Badlands" topography is the most striking feature of this type. It is the least productive of vegetative biomass. No existing, projected, or proposed mines are within this type.

TABLE II-17.--Common plant species by vegetative type

Species	Ponderosa pine savannah	Southeastern grassland	Badlands grassland	Eastern Montana ponderosa pine forest	Central grassland	Undifferentiated stream and lake bottoms
	Rangeland type					
Grasses						
Bluegrass spp.	---	---	---	[2]X	---	[2]X
Bluegrass, sandberg	X	X	X	[2]X	X	---
Bluestem, sand	---	X	---	---	---	---
Bluestem, little	X	---	X	---	---	---
Brome, cheatgrass	---	---	---	[3]*	---	[2,3]X
Buffalograss	X	[1]X	X	---	---	---
Dropseed, sand	---	X	---	---	---	---
Fescue, Idaho	X	---	---	X	---	---
Grama, blue	[2]X	[2]X	[2]X	X	[2,3]X	---
Grama, sideoats	X	---	---	X	---	X
Junegrass, prairie	X	X	---	X	X	---
Muhly, plains	---	X	X	X	---	---
Needlegrass, green	---	[1]X	X	---	X	---
Needle-and-thread	X	X	[2,4]X	X	[2,4]X	X
Reedgrass, plains	---	X	---	---	X	---
Ricegrass, Indian	X	X	---	---	---	---
Saltgrass	---	---	---	---	---	X
Sandreed, prairie	---	[2]X	X	---	---	---
Wheatgrass, bluebunch	[2]X	X	X	[2]X	X	---
Wheatgrass, streambank	---	X	---	---	---	---
Wheatgrass, thickspike	---	X	---	---	---	---
Wheatgrass, western	[2]X	[2]X	[2]X	[2]X	[2,4]X	[2]X
Sedges						
Sedge, needleleaf	X	X	---	X	X	---
Sedge, threadleaf	X	[2]X	---	X	X	---
Forbs						
Biscuitroot	---	X	---	---	---	---
Globemallow, scarlet	---	X	X	---	[3]X	---
Goosefoot spp.	---	---	---	---	---	---
Goosefoot, lambsquarter	---	---	X	---	---	X
Lupine	X	---	---	[3]X	---	---
Onion, wild	---	X	---	---	---	---
Phlox spp.	X	---	X	X	[3]X	---
Plantain, wooly	---	X	---	---	---	X
Pointloco, purple	---	X	---	---	---	---
Scurfpea, breadroot	---	X	---	---	---	---
Stickseed spp.	---	X	---	---	---	---
Sunflower spp.	---	---	---	---	---	X
Wildbuckwheat spp.	X	---	X	X	X	---
Yucca spp.	---	X	---	---	---	---
Shrubs						
Buffaloberry, silver	---	---	---	---	---	X
Greasewood	---	---	[1]X	---	---	---
Juniper, creeping	---	---	X	---	---	---
Pricklypear, plains	[3]X	[3]X	[3]X	---	[3]X	[3]*
Rabbitbrush spp.	---	---	X	---	---	X
Rose spp.	---	X	---	---	---	X
Sagebrush, big	[3]*	[3]X	[3]X	---	[3]X	[3]*
Sagebrush, silver	---	X	X	---	[1]X	X
Sagewort, fringed	[3]*	[3]X	---	---	[3]X	---
Saltbush, shadscale	---	---	[1]X	---	---	---
Snakeweed, broom	[3]*	[3]X	[3]X	---	X	[3]*
Snowberry, common	X	---	---	---	---	X
Snowberry, western	---	---	---	X	---	---
Sumac, skunkbush	X	---	---	X	---	---
Trees						
Cottonwood spp.	---	---	---	---	---	[1]P
Juniper, Rocky Mt.	X	---	---	X	---	---
Pine, ponderosa	[1]X	---	---	[1]X	---	---
Willow, snow	---	---	---	---	---	[1]X
Willow, summit	---	---	---	---	---	[1]X

*Indicator species but relatively uncommon in type.
[1]Distinguishing plant species.
[2]Principal forage grasses.
[3]Species which have increased in percent composition due to overgrazing.
[4]Species which have decreased in percent composition due to overgrazing.

3. Native Grass

The native grass type is composed of the buffalograss subtype and the needle-and-thread/threadleaf sedge subtype. The buffalograss subtype covers almost a fifth of the entire region and represents over 90 percent of the native grass type. Buffalograss is dominant throughout the undulating-to-hilly slopes. This grass is present in adjacent types or subtypes, but not in an even stand throughout, as it is here. Soils are sandy loams to clays with grayish brown or brown topsoil. Threadleaf sedge covers the gravelly ridges; the clay hills common in the type, where they aren't too severely eroded, are covered with patches of thick-spike wheatgrass.

The needle-and-thread/threadleaf sedge subtype, about 2 percent of the region, has a needlegrass aspect distinguished by a high consistency of needle-and-thread and threadleaf sedge. Topography ranges from gently rolling to hilly. Sands and sandy loams predominate with grayish brown topsoil. The sandier areas are easily damaged by overgrazing and are subject to wind erosion. Sagebrush is all but absent from this type, and there are no distinctive species other than needlegrass and thread-leaf sedge. Relatively little forb or shrub production occurs here.

This type does not include existing, projected, or proposed mines within the region, except for pockets included in the Big sagebrush-grass subtype.

4. Big Sagebrush-Grass

The general appearance of this type is very similar to the native grass types; however, buffalograss is a prevalent species. There are pockets of native grass within this type. Sagebrush is normally found in minor quantities throughout the type but may range from being almost totally absent to dominating the aspect. Topography varies from plains to rolling and rough, and the grayish-brown soils are sandy and gravelly to much more abundant heavy clays.

Although not quite as productive as the native grass type, this type produces considerable livestock forage and is very important to wildlife. (See Wildlife, chapter II.)

Six mines in the study area, including portions of the proposed Spring Creek and Pearl mines, are located within the sagebrush-grass type.

5. Ponderosa Pine

The savannah aspect of open stands of pine with a heavy grass understory distinguish this type. The rough, broken land along the Yellowstone River and rocky hills rising from the plains has limited grazing, although the grazing capacity is relatively high. Soils generally are gravelly and poorly developed.

Along with the ponderosa pine-grass type, this type shares a close association with shallow soils underlain with sandstone or shale bedrock. Trees here also provide wildlife cover, livestock shade, and an esthetic landscape.

Both the proposed Spring Creek and Pearl mines fall partially within this type.

6. Riparian

Willow and cottonwood distinguish this type. The topography is bottomland, usually flat, and the soils are rich brown alluvium. Originally very productive in terms of natural forage, much land has been withdrawn for farming. (See Land Use, chapter II.) Plentiful water has allowed considerable overgrazing on the remaining land.

Riparian areas are especially important because they are a crucial source of biological diversity. Riparian areas are scarce in the region and make up a relatively small portion of the land resources. Their degradation has resulted in conditions which adversely influence water quality and quantity, commercial and recreational fisheries, esthetics, and a wide range of fish and wildlife values.

Some existing mines but no projected or proposed mines are in this vegetative type at the broad mapping scale. Many of the mines in the area have perennial or even ephemeral drainages with limited riparian areas, including the three proposed mines. Present regulations protecting alluvial valleys, riparian areas, prime farmlands, and habitat for sensitive, threatened or endangered plant species (see chapter III) effectively preclude significant direct disturbance to riparian areas.

7. Threatened, Endangered, and Noxious Species

Only one threatened species, *Rorippa calycina* (spreading yellowcress) is known to exist in the region. This plant may be found in or near the sandy bottoms of the Yellowstone River from Fort Sarpy (near Forsyth) to Fort Union (Hitchcock and others, 1961). None of this habitat would be directly affected by mining in the study area.

Spring Creek is the only mine known to have noxious weeds. (See FES 79-10.) Three species are known to exist in the permit area: Canada thistle, field morning-glory (or field bindweed), and wild licorice. Perennial sow thistle has been observed less than a mile upstream from the Spring Creek permit area. Others noxious species exist in the vicinity of the Big Sky mine and could invade the site after reclamation. (See DES 78-51.)

G. WILDLIFE

Man has influenced wildlife distribution and population in the region primarily through alteration of habitat. Historical influences

were primarily the elimination of buffalo and introduction of cattle. More recently, expanding human activities and settlements have altered or eliminated wildlife habitat. Current habitats of most wildlife species are assumed to be at or near carrying capacity.

Vegetation has been broadly grouped into five major habitat types: grassland, sagebrush, upland shrub, ponderosa pine, and riparian. Table II-16 shows the approximate acreages of vegetation types that correspond closely with these major habitat types.

1. Regional Overview

Big game species in the region include mule deer, antelope, and a few white-tailed deer. Mule deer and antelope hunting is popular, attracting both resident and out-of-state hunters. The most adverse effect of mining to date on big game is alteration of native habitats. This is most severe where the mine encroaches on winter ranges, especially those portions of the winter range which are crucial during severe winters.

Mule deer generally occupy sagebrush-grassland and ponderosa pine habitats. They also use riparian habitat during spring, summer, and fall. Broken terrain provides important cover in those habitat types. Browse is an important component of their diet. There are 13 known winter ranges for mule deer in the Decker and Colstrip areas. Mule deer do not appear to migrate in southeast Montana.

Antelope usually occupy open, rolling grassland and sagebrush-grassland habitats. During the winter antelope diet is predominantly sagebrush. Antelope move more widely than deer in the region, and fencing can adversely affect their movements. There are 12 known antelope winter ranges in the Decker and Colstrip areas.

White-tailed deer primarily use riparian and ponderosa pine habitats in and around the Custer National Forest and along the Tongue and Powder Rivers. Whitetails are less common than mule deer or antelope.

Sage grouse, sharp-tailed grouse, ring-necked pheasants, and Merriam's turkeys are the primary game birds in the region. Grouse species are most affected by losses of leks (display/mating areas), nesting sites, and wintering areas. Sage grouse are almost totally dependent on sagebrush for food and cover, while sharp-tailed grouse utilize various habitats, particularly prairie vegetation types interspersed with brushy coulees and scattered stands of ponderosa pine. Merriam's turkeys are mostly found on the Ashland Division of the Custer National Forest.

Raptor species include eagles, hawks, falcons, and owls. Golden eagles and red-tailed hawks prey on small mammals, such as cottontails. Bald eagles are an endangered species and are discussed below. Both species of eagles are protected by Federal law. Marsh hawks and American

kestrels (sparrow hawks) feed on small rodents such as mice. The prairie falcon and the endangered peregrine falcon (discussed below) prey primarily on small birds.

Most small mammals in the region occupy ponderosa pine and upland shrub habitats, with fewer species in grasslands. Numbers of western deer mice have increased rapidly on early mineland reclamation but have then stabilized at lower population levels (ECON, 1976).

Songbirds occupy all habitats. A preliminary study near Decker (Mikol, 1977) indicates that riparian habitat supports the greatest number of species, followed, in order, by ponderosa pine, sagebrush-grassland, and grassland habitats.

Bullsnakes and prairie rattlesnakes are the most common snakes. Bullsnakes use a variety of habitats; rattlesnakes are commonly associated with rock outcrops in shrub/grassland habitats. Sagebrush lizards occur in sandstone breaks and outcrops of the sagebrush-grassland habitat. Leopard frogs are the most common amphibian and occupy aquatic/riparian habitat associations.

Table II-18 lists ratings of streams for fish in the region. The Tongue River and Tongue River Reservoir are the most important sport fishing waters in the area of proposed or projected mining. Walleye, northern pike, crappie, smallmouth bass, and brown trout are the primary sport fisheries of these habitats.

TABLE II-18.--State of Montana stream fisheries classifications for the northern Powder River basin

[Source: Montana Department of Fish and Game, 1978]

Stream	Fishery rating
Powder River	1
Mizpah Creek	3
Little Powder River	3
Tongue River I (mouth to Beaver Creek)	2
Tongue River II (Beaver Creek to Tongue River dam)	3
Tongue River II (Tongue River dam to Wyo. line)	2
Pumpkin Creek	3
Otter Creek	3
Hanging Woman Creek	2
Rosebud Creek	2

Ratings definitions:

1: Highest-values fisheries resource.
2: High-priority fisheries resource.
3: Substantial fishery resource.
4: Limited fishery resource.

a. Threatened and endangered species

The region includes current and/or historic ranges of the whooping crane, peregrine falcon, black-footed ferret, and bald eagle. The U.S. Fish and Wildlife Service (FWS) has indicated that none of these species has critical habitat in the region. Baseline studies have not revealed critical habitats of threatened and endangered species on any of the proposed minesites.

Migrating whooping cranes rarely stop in the region. The nearest recorded migration stop is in the vicinity of Powderville, well to the east of the proposed developments (Flath, oral commun., 1979).

Peregrine falcons have historically nested in eastern Montana and possibly in suitable sites in the region. Historic nesting sites may offer the best potential for nesting use by peregrine falcons.

Various sightings of black-footed ferrets have been reported throughout the region since 1910 (Division of Animal Damage Control, FWS, Billings, MT; Yannone, 1973). The most recent confirmed sighting was in 1977 in Carter County, just east of the region. Ferrets are difficult to observe because of their secretive nature and because they are so rare.

Bald eagles use riparian and cliff areas of the Tongue River below the reservoir. Fish is a staple in their diet.

2. Subregional Analysis

Most of the information on wildlife has been gathered in two subregions which include most of the existing and projected mines in the region.

a. Decker subregion

The U.S. Fish and Wildlife Service has established a 572-square-mile area north of Sheridan, Wyoming, to study the effects of coal mining on wildlife. Wildlife habitats that would be impacted by mining in the subregion are shown in figures II-34, II-35, and II-36.

The Decker subregion is predominantly sagebrush-grassland and grassland habitat types interspersed with ponderosa pine, upland shrub, and a small amount of agricultural habitat types. Riparian and aquatic habitats of the Tongue River Reservoir and segments of the river above and below the reservoir are also included.

These habitats are occupied by mule deer, white-tailed deer, antelope, various small mammals, sage and sharp-tailed grouse, a number of raptorial birds, and diverse small non-game birds, amphibians, reptiles, and fishes. There are potential habitats for the endangered peregrine falcon and black-footed ferret. Bald eagles use open-water stretches of the Tongue River below the reservoir during the winter and early spring.

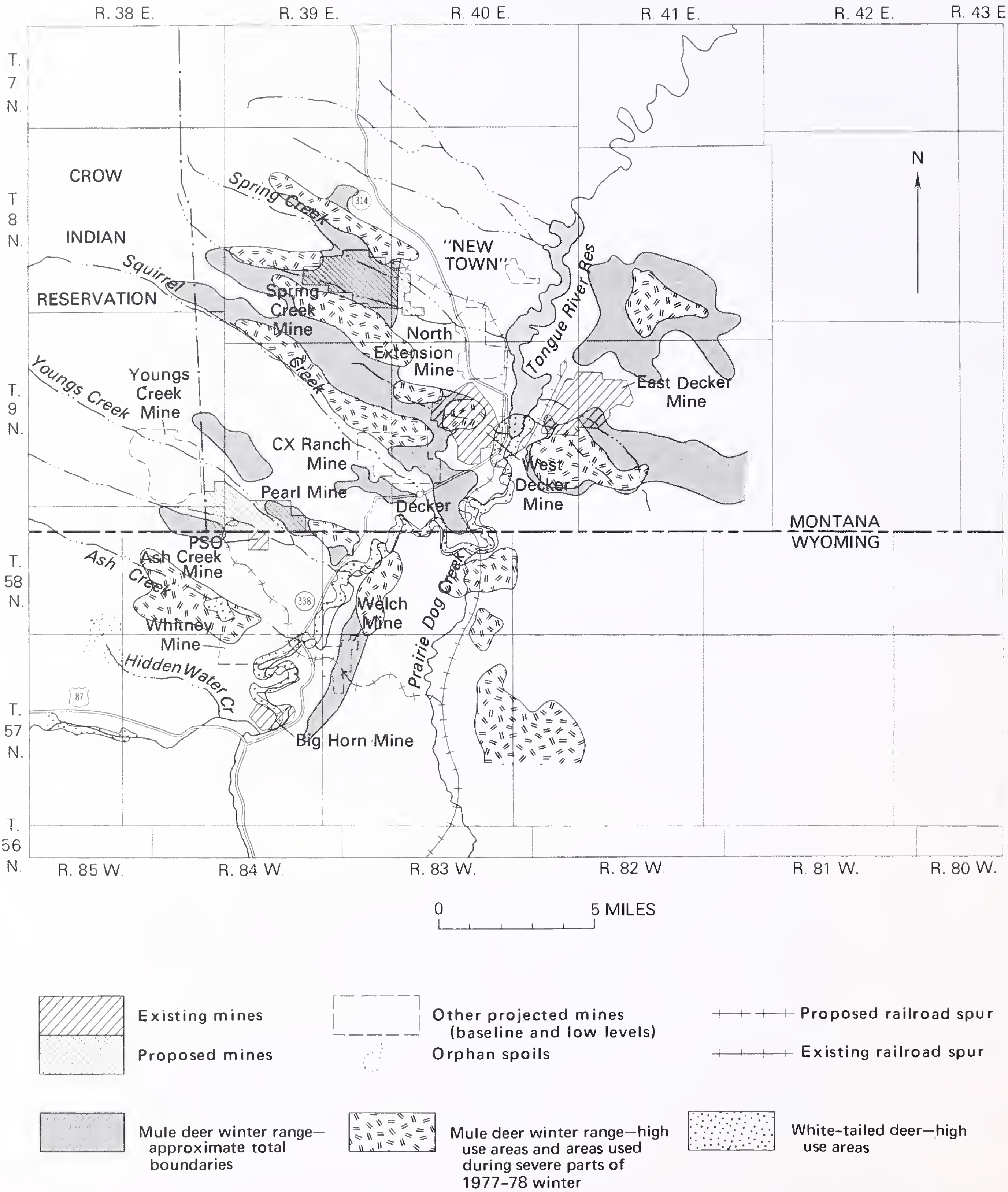


FIGURE II-34.--Mule deer winter ranges in the Decker subregion.

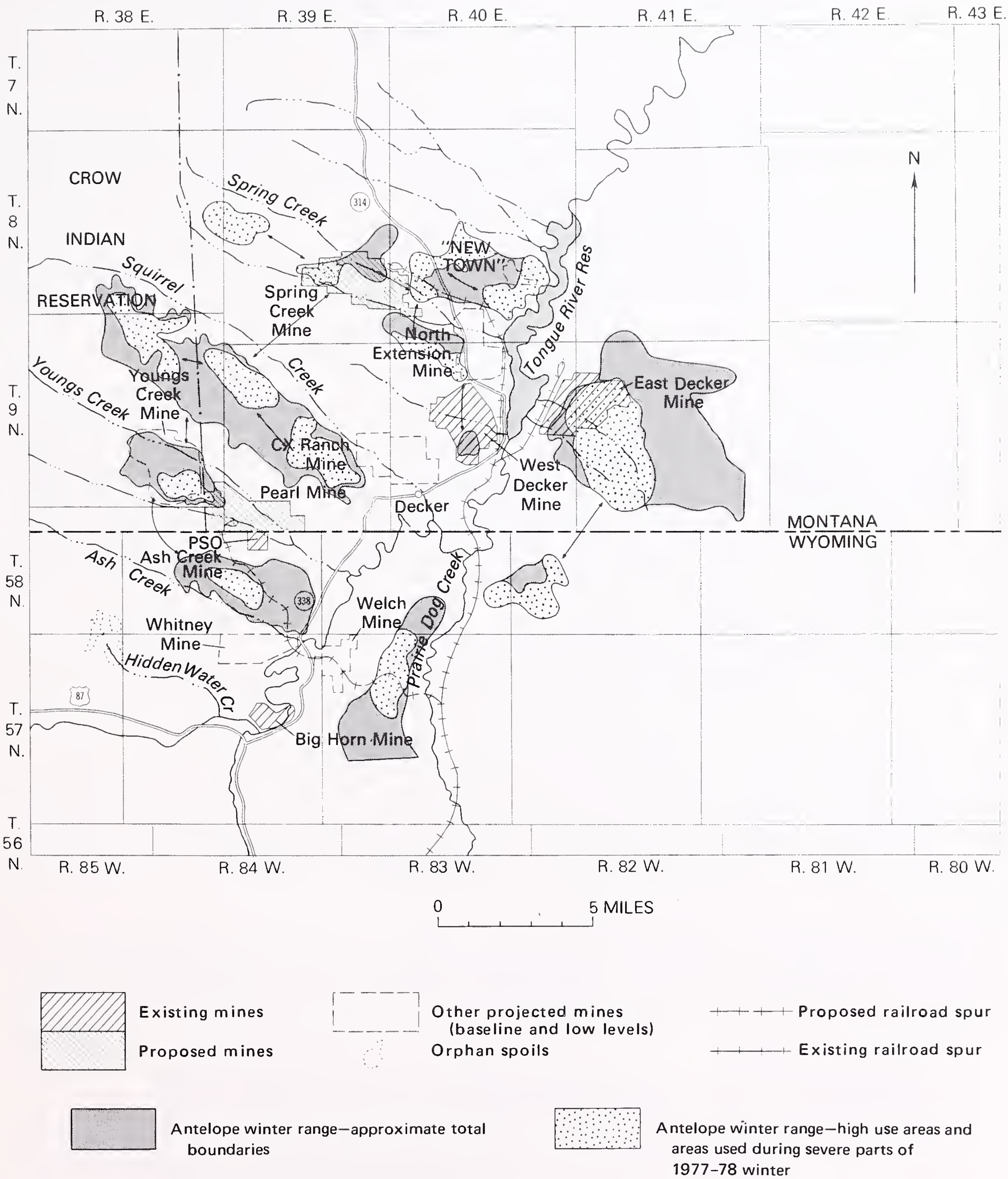


FIGURE II-35.--Antelope winter ranges in the Decker subregion.

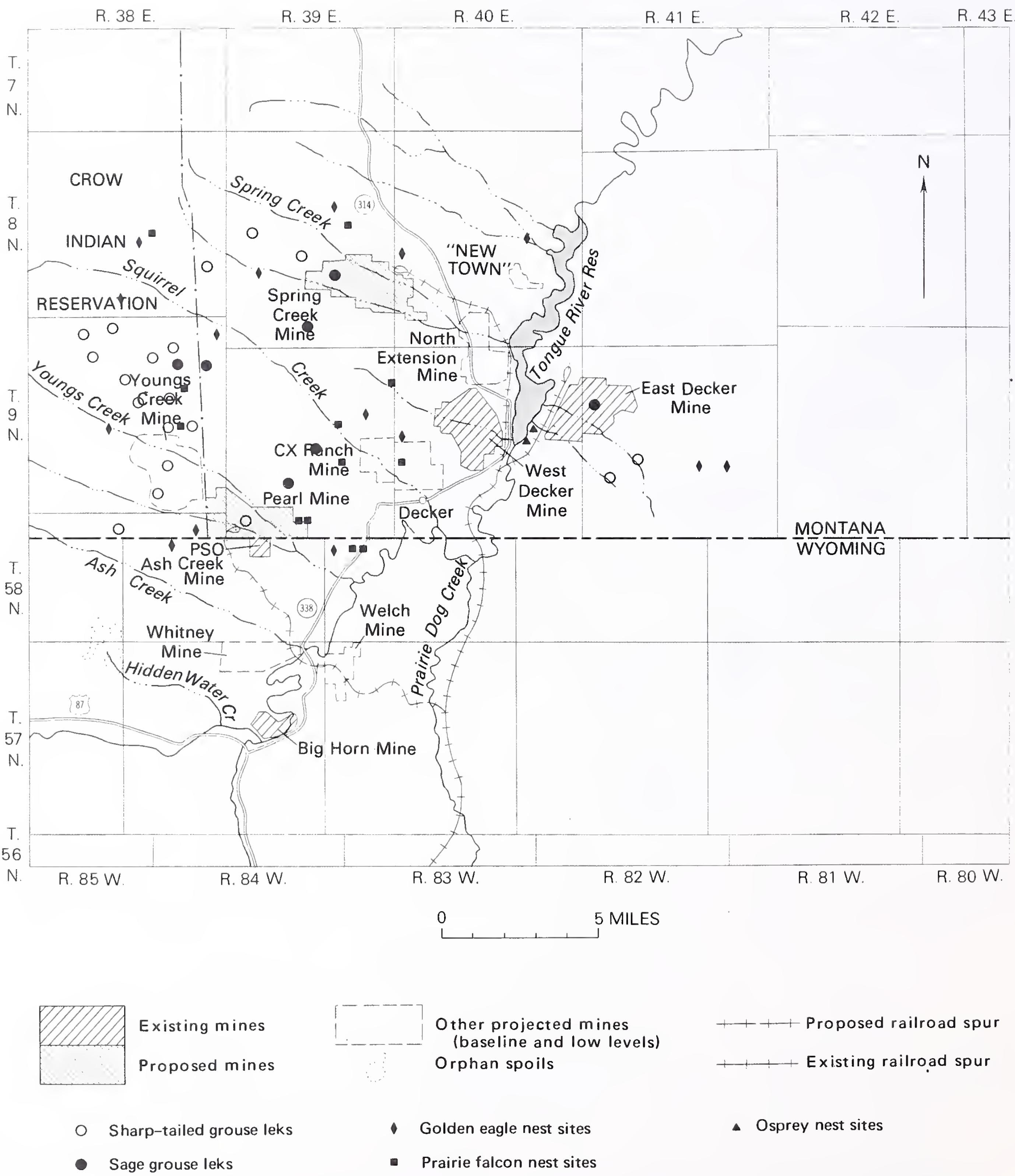


FIGURE II-36.--Raptor and game bird use areas in the Decker subregion.

Eight mule deer winter ranges have been identified in the subregion (fig. II-34). Within these winter ranges seven crucial use areas (concentration areas during the 1977-78 winter) have been identified. There are nine known antelope winter ranges (fig. II-35), which include ten crucial use areas.

At least 24 sharp-tailed grouse leks and nine sage grouse leks occur in the subregion (fig. II-36). U.S. Fish and Wildlife Service surveys have located 17 golden eagle nests and 12 prairie falcon nests (fig. II-36). Several nests of other raptors have also been located.

The Tongue River and the Tongue River Reservoir are among the few good fishing areas in southeastern Montana. Game fish of these waters are valued by local fishermen.

b. Colstrip subregion

An arbitrary subregion of nearly 450 square miles (fig. II-37) includes important wildlife habitats around the proposed Big Sky expansion and Colstrip generating units. Since 1973, Ecological Consulting Service (ECON) has monitored 2 wildlife study areas in that subregion (ECON, 1976a; 1976b) covering a total of 213 square miles around the Big Sky and Rosebud mines. The wildlife resources of the Colstrip subregion are similar to those of the Decker subregion, although ring-necked pheasant would be more affected by mining around Colstrip.

The subregion has rolling sagebrush-grassland and grassland habitat types, interspersed with ponderosa pine hills in the eastern portion of the area. These features blend into the more broken features of ponderosa pine slopes and ridges at the western edge of the subregion.

The subregion encompasses known important habitats of at least four wildlife species. Three mule deer and three antelope winter ranges, 33 sharp-tailed grouse leks, and four sage grouse leks have been located (fig. II-37). The endangered peregrine falcon is a historic visitor, and has been recently sighted in the subregion. Cliff areas in the subregion are potential habitat for this falcon and several other raptors.

Upland shrub and timber types of the Colstrip area are important habitats for big game and grouse species, as well as for a variety of non-game animals, birds, and reptiles. Grassland habitats are important to a variety of wildlife but are not as diverse in species as other habitat types.

Riparian habitat along the east fork of Armell's Creek is used by ring-necked pheasants, white-tailed deer, and a variety of game and non-game mammals, birds, reptiles, and amphibians. The east fork also has a minor fishery.

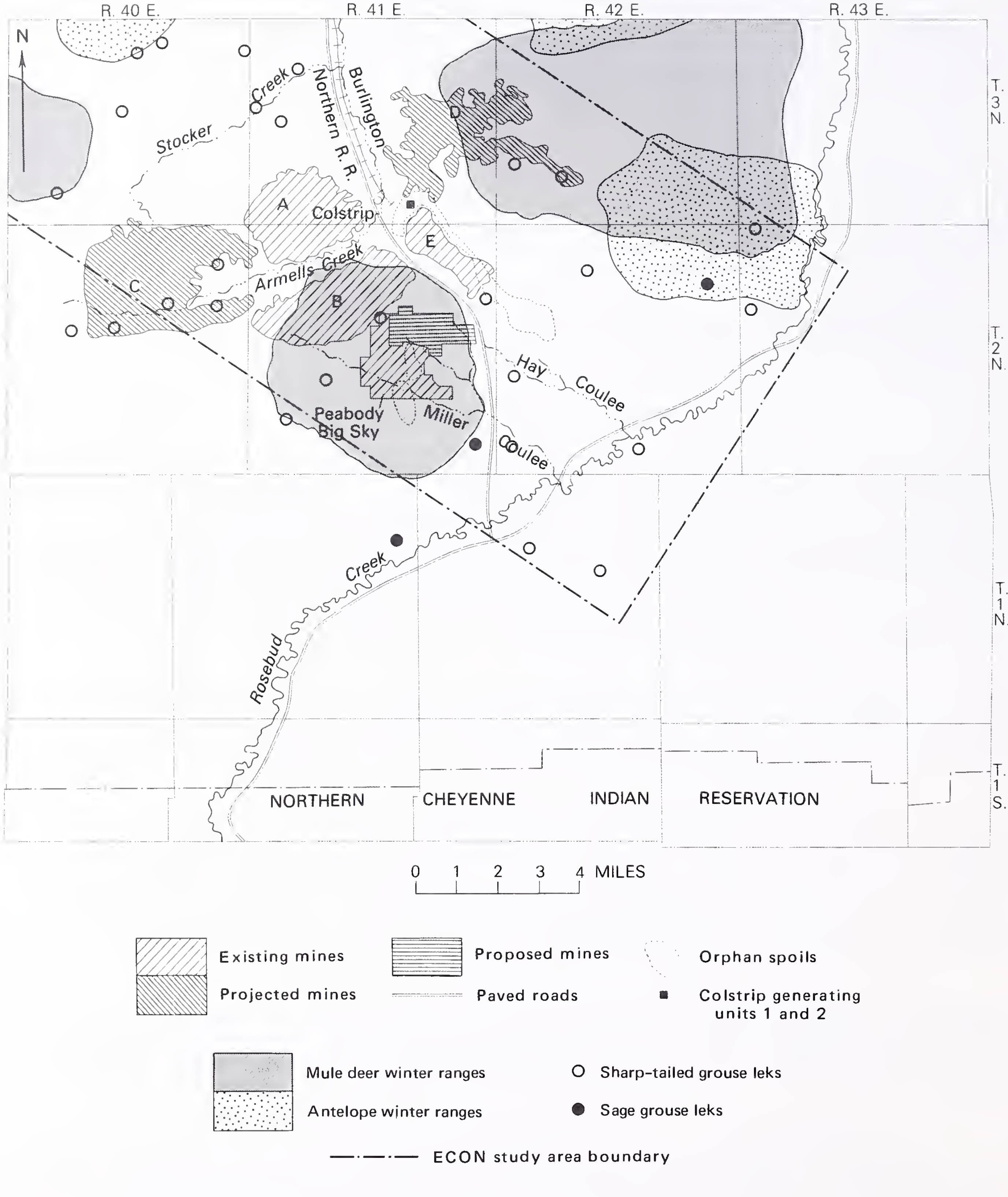


FIGURE II-37.--Wildlife use areas in the Colstrip subregion.

H. SOCIAL ENVIRONMENT

1. Social and Economic History

The history of the study area is divided into four periods in order to show similarities and contrasts between the people, the environment, and time periods.

a. Native American period--12,000 B.C. to A.D. 1880

Many Native American peoples inhabited the Great Plains. The earliest known inhabitants were nomadic hunter-gatherers who enjoyed a period of favorable climate. Remnants of the early prehistoric Indian can be found at various archeological sites throughout the area, particularly on the Spring Creek minesite near Decker. (See Cultural Resources.)

The introduction of horses and other contacts with white society began a brief era during which the Indians prospered and were nomadic. They depended on intertribal trading, fur trading with the white culture, and a natural abundance of wildlife (particularly the buffalo) for a livelihood (Haines, 1971; Lowie, 1954; Weist, 1977).

Constant pressures from an expanding white culture after the Civil War forced the Plains Indians into enclaves on the northern Great Plains. The principle tribes to be pushed in the Tongue and Powder River areas were the Sioux, Cheyenne, and Crow. The Crow were allied with the Government and had come to the area earlier. Large-scale warfare erupted in the 1860's and 1870's, with five major battles occurring in the study area. In 1865, volunteers under General Connors fought Indians near Broadus but were eventually forced into an inglorious retreat. The second and most famous battle was the complete rout of the Seventh Cavalry at the Little Big Horn.

After the Little Big Horn battle, the disquieted Army began winter campaigns against the Indians. These culminated in the Reynolds battle along the Powder River, in which an entire village of Northern Cheyenne and Sioux was destroyed; the Rosebud Creek Battle, which the Indians also lost; and the Battle of Pyramid Butte in 1877, between the warriors of Crazy Horse and forces of Colonel Miles, near the mouth of Hanging Woman Creek on the Tongue River. The Reynolds battlefield has been determined eligible for the National Register, and the Rosebud Battlefield is now listed in the National Register and is a State Park.

By the 1880's, the Sioux, Cheyenne, and other warlike tribes had been placed on reservations. The Cheyenne were split into two reservations, one near the Tongue River and the other in Oklahoma. The Crow remained on a reservation west and south of the Cheyenne's Tongue River Reservation. Once the Indian hostilities were resolved, the northern Powder River area was opened for the first time to serious white settlement (Lowies, 1935; Weist, 1977, Osgood, 1929).

b. White settlement period--1880 to 1950

Trappers and miners were the first to penetrate the Indian country of the northern Great Plains. Resource use on a large scale did not begin until foreign and domestic investors turned the bison lands into cattle country. The Federal Government promoted the so-called "beef bonanza" by opening large areas of the public domain to grazing, and by clearing the land of hostile Indians at considerable expense. Lucrative Federal contracts to supply reservations with beef, along with the eastern market, allowed the cattle industry to expand rapidly. A severe winter in 1886-87 decimated the herds. An overgrazed and eroding land was left in the wake of the beef bonanza (Dale, 1960).

The town of Sheridan was established in the 1880's in the southern part of the area. The town quickly grew from a population of 280 in 1890 to 1,560 by 1900. Most of this growth was due to the establishment of the Union Pacific Railroad, homesteading, and a more permanent cattle industry. These developments, in turn, fostered deep mining of coal seams along the Tongue River. The coal was used for home heating and for fueling the railroad. Sheridan in the 1890's was a boomtown: its population grew at an annual rate of 45 percent through the decade. Sheridan County grew rapidly from 1900 to 1910.

C. N. Deitz of Omaha opened the first commercial coal mine in Sheridan County in 1893. Other mines sprang up in Monarch, Carneyville, Kleenburn, Acme, and elsewhere. The early mines reportedly employed over 5,000 people, and had a capital investment of over $4 million (Larson, 1965). Coal mining remained a steady mode of employment with peak production occurring during World War II.

The history of the northern part of the area evolved primarily along the river systems which served as natural transportation corridors for river and rail travel. The Yellowstone and Big Horn Rivers were traversed by 18th century explorers and 19th century fur traders. With the construction of the Northern Pacific Railroad up the Yellowstone Valley in 1881, the river ceased to play a direct role in commercial transportation. The first northern transcontinental rail link was established in 1883, opening Montana's resources to the burgeoning urban markets.

Along with the construction of rail system, the northern part of the area experienced boom growth as a result of military action against the Indians. Many forts were built along the rivers to protect the white settlers. In some cases, these forts eventually became permanent trade centers, such as Miles City which originally started as Fort Keogh.

Although both the northern and southern parts of the area experienced boom-bust economic growth cycles, the northern part was more dominated by agricultural growth than the Sheridan area. Miles City became a regional livestock center along with other agricultural activity. Although mining began at Colstrip in 1924, it did not begin

large scale coal production until the late 1960's, and it was relatively isolated from the primarily agrarian society.

A wave of homesteading in the early 20th century contributed to a relatively unstable economic life. Following the decline of open range cattle grazing in the 1880's, the best arable land was deeded by ranchers, leaving little good land available for the later wave of homesteaders. However, extensive dry farming settlement occurred in the area until the late 1910's. The period of relative prosperity was short-lived; severe recurring dry periods in the 1920's and 1930's forced many homesteaders to leave. The population of the area decreased during the 1930's, paralleling the great exodus which was taking place throughout eastern Montana. For those who remained, agricultural prosperity did not return until prices rose during World War II (Toole, 1977).

c. Post-World War II period

New kinds of economic development began in the area following World War II. Large corporations located reserves of oil and uranium in the area. The Federal Government promoted extraction of the rich coal reserves along the Tongue River. Oil production, however, was the primary new economic activity, causing a population increase in Powder River and Sheridan Counties in the 1950's.

The development of a Federal interstate highway system encouraged a shift in transportation from railways to trucking. Automobile tourism and sport hunting also increased following the war, when visitors from all over the country came to enjoy the Big Horn Mountains and surrounding lands. The advent of trucking and tourism as major industries promoted oil development. Concurrently, the open-pit coal mines at Colstrip were closed in 1957 when the Northern Pacific Railroad converted to diesel locomotives (Morgan, 1966).

The increasing dependence on automobiles and trucking can be seen in the increase in highway user tax revenues. Between 1950 and 1961, revenues from the highway user taxes increased from $7.7 million to $16 million in Wyoming, and from $15.6 million to $26.4 million in Montana. The Federal Government also contributed large sums to spur highway development. In both Montana and Wyoming the new roads and mobile population helped set the stage for fossil fuel development by providing a mobile labor force and an industrial supply system.

d. Rapid change and uncertainty--1970 to present

Changes in the world economy, including a rise in the price of oil, made coal an attractive source of energy. The price of coal also increased, which made it economical to strip mine Great Plains coal. Boom-bust economic and social conditions again returned to the region with Colstrip swinging into production along with two large coal-fired generators constructed to export electricity. Montana's coal production rose from 3.5 million tons in 1970 to 22.2 million tons in 1975. Over 60 percent

of this production came from Big Horn County. From 1975 to the present coal production has increased at rates less than anticipated due to soft coal markets, environmental constraints, undeveloped regional transportation systems, and uncertain Government energy policies.

2. Population

From 1940 to 1970, the population of the study area declined at an average rate of 2.4 percent per year (fig. IV-11; table II-19). Rural populations declined more than urban populations: Treasure County's population declined 29 percent, while Custer County's grew 16 percent, largely owing to the importance of Miles City as a regional trade center and the oil and gas boom in Williston Basin.

From 1970 to 1976, on the other hand, regional populations grew 16 percent. (See table II-19.) Rosebud County grew the fastest (59 percent), mainly because of the opening of the Rosebud and Big Sky mines and the construction of generating units 1 and 2; Colstrip grew nearly 700 percent, and Forsyth grew 31 percent. Both Sheridan County and Sheridan itself grew about 17 percent, and Big Horn County grew about 6 percent.

Colstrip and Forsyth are approaching boomtown growth (population growth too rapid to manage). From 1970 to 1976, Rosebud County grew an average of 8 percent per year; Colstrip grew 41 percent per year, and Forsyth grew 4 percent per year. Big Horn County grew about 1 percent per year. The Sheridan urban area (Sheridan, Dayton, and Ranchester) grew 3.5 percent per year. Sheridan is already experiencing boomtown problems (Thompson and others, 1978) because of its apparent reluctance to plan for rapid growth (EPA, 1977).

The only substantial minority populations in the study area are the Northern Cheyenne and Crow Indians. The 2,600 Northern Cheyenne Indians in the study area make up about 20 percent of the population of Rosebud County; and the 4,400 Crow Indians in the area make up about 30 percent of the population of Big Horn County.

3. Social Environment

In the decades before the resumption of mining at Colstrip in 1968, the study area (for this discipline Rosebud, Treasure, Big Horn, Powder River, Custer, and Sheridan Counties) was dominantly rural and agricultural. The great distances and isolation in the Great Plains presented social costs, including too few people and too great distances to efficiently provide many government, social, and legal services.

As farms and ranches consolidated into larger units, many young people left the area; businesses in towns saw their incomes decline. Because of the prevailing age structure of the population, local and county governments found it difficult to staff their full complement

TABLE II-19.--Population growth and decline of the Northern Powder River Basin study area, 1940 to 1990 - the baseline*

County	1940	1950	Percent change	1960	Percent change	1970	Percent change	1976	Percent change 1970-76
Actual population changes									
Big Horn------	10,419	9,824	-5.7	10,007	+1.9	10,057	+0.5	10,618	+5.6
Custer--------	10,422	12,661	+21.5	13,227	+4.5	12,174	-8.0	12,979	+6.6
Powder River--	3,159	2,693	-14.8	2,485	-7.7	2,862	+15.2	3,167	+10.7
Rosebud-------	6,497	6,570	+1.1	6,187	-5.8	6,032	-2.5	9,578	+58.8
Treasure------	1,499	1,402	-6.5	1,345	-4.1	1,069	-20.5	1,228	+14.9
Sheridan------	19,255	20,185	+4.8	18,989	-5.9	17,852	-6.0	20,800	+16.5
Region total	51,251	53,335	+9.1	52,240	-2.1	50,046	-4.2	58,370	+16.6

County	1980	Percent change 1970-80	1990	Percent change	Percent change 1940-70	Percent change 1940-90	Percent change 1970-90
Projected population changes							
Big Horn------	11,602	+15.4	14,524	+25.2	-3.5	+39.4	+44.4
Custer†-------	13,523	+11.1	14,076	+4.1	+16.8	+35.1	+15.6
Powder River--	2,320	-18.9	2,714	+17.0	-9.4	-14.1	-5.2
Rosebud-------	9,720	+61.1	13,064	+34.4	-7.2	+101.1	+116.6
Treasure††----	1,220	+14.1	1,220	0	-28.7	-18.6	+14.1
Sheridan------	23,733	+32.9	30,660	+29.2	-7.3	+59.2	+71.7
Region total	62,118	+24.1	76,258	22.8	-2.4	+48.8	+52.4

*Population estimates for the years 1980 and 1990 are projections from the Coal Town II model; 1976 population figures are actual census figures from special county census for all counties except Powder River.

†The Coal Town II model did not project populations figures for Custer County for 1980 and 1990. These projections are from a Multi-variant Regression Analysis - source: John M. McQuiston, "Final Draft: Regression Analysis and Summary of the Impact of Mining Industry on Big Horn, Custer, Powder River, Rosebud, Treasure Counties, Montana, and Sheridan County, Wyoming." University of Montana, Missoula, 1978.

††Treasure County is expected to continue declining in population. The Coal Town II model shows it levelling off at 1,220 people.

of elective and appointive offices. Teachers and classrooms were underutilized. Access to medical facilities and doctors was limited.[9]

Institutions were patterned after more humid eastern areas and did not recognize the demands of the semiarid environment. For example, the eastern mortgage system was adopted in the Great Plains. As a result, ranchers had to make periodic payments on loans even when droughts wiped out their profits several years in succession. Children whose help was needed to run ranches had to board in towns to attend school.

Many local residents and government officials welcomed, even encouraged, coal development in the hope that economic and population growth would alleviate problems related to space, isolation, and a declining population. Coal mining and electric generation beginning about 1970 brought an influx of new people, making possible better delivery of many government, social, and medical services, but at the cost of a way of life desired by many long-time residents. Growth has not been orderly, controlled, or well-planned for, largely because institutions adopted from the eastern states did not meet the demands of the semi-arid environment. Rapid growth due to mining and coal conversion projects has not efficiently developed community resources nor has it equitably distributed those resources (ERDA, 1977).

Employment increases due to mining have not been evenly distributed: Sheridan and Rosebud Counties accounted for over 80 percent of the population increase in the study area between 1970 and 1977. Powder River and Big Horn Counties still had net out-migration during this period.

Understanding and forecasting impacts on society in coal development communities requires comparative study of these communities over time, with special attention to institutional and societal features; unfortunately, this has not been done for the study area. The analysis in this EIS consists of informed guesses as to effects of coal development on social organization and individual well-being, relying on demographic and economic trend analyses and the few existing attitude surveys.

a. Adverse effects on individuals

Growing urbanization has contributed to local feelings of alienation and a loss of a sense of community (Gold, 1974). This is most apparent in Colstrip, where premining residents found that their community no longer seemed to belong to them. Examples found by Thompson (1978) in Sheridan County include trespassing by newcomers (disrupting agricultural operations), congestion of local roads, fears that the area will be subjected to urban problems associated with industry and overcrowding, and the loss of long-term residents' influence over local affairs.

---

[9]These conclusions and those that follow are based in part on interviews by team members (on file report), and on Webb (1931), Kranzel and McDonald (1971), and Montana State University (1954).

Ranchers have been losing their former influence over the political, social, and business systems of the area to the new mining industrialists (Gold, 1975). Local merchants have shifted from catering to the needs of ranchers to the needs of the new mining- and construction-related population. County commissioners and town governments have been preoccupied with coal-related activities, thus neglecting the needs of their ranching constituents.

Among ranchers there are feelings of a loss of power and ability to influence their lives. There is also the desire for bewildering and overwhelming social changes to stop long enough to allow for adjustment, so that they can examine their inclinations and abilities to deal with more changes (Gold, 1974). The pervasive climate of uncertainty is leading to reactions of future shock (Meadowlark, 1978).

The elderly, the poor, minorities, and those on fixed incomes have been most affected by mining. Increased consumer demand has caused local inflation, the overcrowding of services (especially medical), higher rents, and costs of basic necessities. This condition is especially significant in Sheridan County, which has a disproportionate number of elderly and persons on low or fixed incomes, the result of Sheridan being an attractive retirement center. The county's percentage of persons over 65 years of age (approximately 18 percent) is twice that of Wyoming as a whole. Another 15 percent of the population is in the low-income category. In a study of rapid growth communities, HUD (1976) found that "the heavy and rapidly increasing demand, linked with a small and limited supply of housing, always results in an increase in prices for housing and lots and in rents."

The high wages of many newcomers allows them to compete at an advantage with most long-time residents and others for goods and services. Thus, the social cost of inflation is borne most heavily by those least able to pay. This may have caused feelings of relative deprivation which may occur when actual achievement compares unfavorably with the achievements of others. For example, social dissatisfaction among Sheridan's low-income people may develop if increased economic opportunities do not materialize or are taken by outsiders.

Although the mining family, as a social unit, apparently benefits from the high personal incomes, the benefits may not be enough to offset some of the social costs wives face. Many wives have been confronted by conditions associated with boom towns, including crowding, undesirable housing, and poor services.

Adding to the specific stress that wives and the elderly experience because of housing conditions and inflation is a general malaise which exists for many community residents. HUD (1976) identified the causes of this malaise as a speeded pace of life, congestion and overcrowding, inflation in prices, fear of change in lifestyles for present residents, lack of activities and belonging for newcomer families, and alcoholism and mental health problems.

Although rapid population growth may cause general dissatisfaction throughout the community, it is again the wives and the elderly who are most likely to have feelings of relative deprivation. They compare themselves unfavorably to others within their community and to the relatively better position of friends and associates.

b. Benefits to individuals

Increased employment and income has generally benefitted individuals and communities; however, some segments of the population identified in the previous section have not shared these benefits.

Increased personal income has helped spur demand for new leisure opportunities (Massey, 1977, 1978; HUD, 1976). Growing urbanization of the impacted counties has resulted in a greater variety of goods and services. New construction provided some architectural diversity. Young people especially are well-served by the growing variety of opportunities and the resulting increase in freedom of choice--including a greater likelihood of being able to find employment in their local areas.

According to both the head of the Social and Rehabilitation Services office in Rosebud County and the Public Assistance and Social Services Office in Sheridan County, increasing employment reduced the need for food stamps as a support for family nutrition (Mike Kennedy, oral commun., SRS, 1979; Mary Brooks, DPASS). Higher incomes from coal mining may make better nutrition possible and it reduces the need for outside subsidies for family nutrition. From 1971-78 in Sheridan County, Aid to Families with Dependent Children (AFDC) caseloads increased about 50 percent while foodstamp caseloads decreased about 39 percent. This compares to the statewide (Wyoming) trend in which AFDC caseloads increased 44 percent and foodstamp caseloads increased 15 percent during the 1970-77 period. Thus, at least in Sheridan County, rapid urbanization does not appear to lead to large increases in welfare payments. Thompson and others (1978) concluded that "this is consistent with the fact that urbanization produces jobs, reducing unemployment and need for welfare."

The high wages paid to workers account for their ability to support their families without outside assistance. Thompson and others (1978) found that mining salaries averaging $16,484 were significantly higher than prior average annual incomes. Local people (those who had lived in the area at least a year) shared in these new higher salaries to some degree: Mountain West (1975) found that about 40 percent of the average construction project force were local people; 70 percent of the employees surveyed at the Decker mine were local workers (Thompson and others, 1978).

Local communities also benefited as greater personal incomes (from both wages and business profits) led to greater purchasing power and, therefore, to a larger tax base (Johnson and White, 1975). This came from increased income taxes (in Montana) or sales taxes (in Wyoming).

Generally, however, property taxes in both States allowed governments in impacted counties to pay their own way. Johnson and White (1975) found that "between fiscal 1966 and fiscal 1975, Rosebud County taxpayers fared better with respect to changes in county government levies than did a good many other Montanans in neighboring counties or similar sized counties." The increased ability to raise monies locally may be coupled with increased professionalism and expertise in the community. This appears to develop into a sense of pride in their ability to cope with growth and change (Les Jayne, Head Sheridan County Planning Office, oral commun., 1979). If the needed skills and funds to deal with growth and provide services are available locally, the need for outside subsidies is reduced.

I. ECONOMICS

1. Employment

Agriculture has long been the primary source of employment in the six-county study area (Big Horn, Rosebud, Powder River, Custer, Treasure, and Sheridan Counties). Employment in agriculture is declining, however, with mining and construction assuming increasing importance. These trends are likely to continue and are almost entirely independent of each other. In Sheridan County, trade is becoming increasingly important.

a. Past trends

From 1940 to 1970, employment in the Montana portion of the study area increased 14 percent, less than half the 37 percent increase statewide. During the same period, employment in the United States increased nearly 75 percent. Only nine States had a lower rate of job formation than Montana during the period (U.S. Department of Commerce, 1975). Basic industry's share of total employment in the Montana study area decreased from 61 percent to 37 percent, due mainly to a 45 percent decline in agricultural employment. The relative size of the State's basic sector also declined, from 55 percent to 33 percent. The relatively large proportion of agricultural employment in the area accounted for the greater change (tables II-20, II-21).

Employment in agriculture declined because farms and ranches became larger and more capital-intensive. Although regional agricultural employment decreased markedly, production did not. Along with a trend toward specialization in cash crops, harvested acreage decreased less than 3 percent between the 1940-44 average and the 1970-74 average. Total livestock production increased slightly.

After several decades of stable population, the area began to grow from 1970 to 1975, even though employment in agriculture and manufacturing declined. Growth came from increasing employment in mining, construction, Federal Government, and derivative employment in trade and services caused by mining (table II-22).

TABLE II-20.--Employment by broad industry and sector, 1940

[Source: U.S. Department of Commerce, 1975]

	Big Horn County	Custer County	Powder River County	Rosebud County	Treasure County	Montana study area	State of Montana	Sheridan Wyoming
Basic sector:								
Agriculture	1,859	785	908	1,040	318	4,910	60,480	1,706
Mining	6	17	5	1	0	29	13,780	358
Manufacturing	118	84	6	31	2	241	13,929	337
Federal Government	59	127	20	99	13	318	5,241	112
Construction (part)[1]	55	98	0	17	6	176	3,005	72
TCU[2] (part)[3]	0	446	0	42	8	496	5,317	259
Total economic base	2,097	1,557	939	1,230	347	6,170	101,752	2,844
Ancillary sector:								
Trade	351	674	45	236	54	1,360	29,707	1,134
FIRE[4]	25	80	4	16	2	127	3,573	120
Services	408	647	112	331	42	1,540	31,175	1,461
Construction (remainder)	99	108	26	67	16	316	5,957	198
TCU[2] (remainder)	67	175	7	109	26	384	9,724	323
Local and State government	50	107	17	84	11	269	3,676	86
Total ancillary sector	1,000	1,791	211	843	151	3,996	83,812	3,322
Total employment	3,097	3,348	1,150	2,073	498	10,166	185,564	6,166

[1] Proportion greater than 0.0321 of total employment.
[2] Transportation, communications and utilities.
[3] Proportion greater than 0.0524 of total employment.
[4] Finance, insurance, and real estate.

TABLE II-21.--Employment by broad industry and sector, 1970

[Source: U.S. Department of Commerce, 1972]

	Big Horn County	Custer County	Powder River County	Rosebud County	Treasure County	Montana study area	State of Montana	Sheridan Wyoming
Basic sector:								
Agriculture[1]	1,068	608	532	686	259	3,153	38,951	812
Mining	67	79	99	[2]65	[2]0	310	6,559	[2]182
Manufacturing	329	109	[2]0	[2]191	2	631	23,822	366
Federal Government	333	310	25	108	11	787	18,075	629
Construction (part)[3]	0	0	[2]0	0	0	0	0	70
TCU[4] (part)[5]	0	139	[2]0	61	3	203	1,143	0
Total economic base	1,797	1,245	656	1,111	275	5,084	88,550	2,059
Ancillary sector:								
Trade	435	1,142	107	212	39	1,935	48,867	1,473
FIRE[6]	58	126	[2]11	19	[2]2	216	7,936	194
Services[7]	895	1,474	230	702	[2]73	3,374	70,066	2,178
Construction (remainder)	59	266	[2]25	29	10	389	11,144	446
TCU[4] (remainder)	102	300	[2]24	146	28	600	16,250	368
Local and State government	391	705	148	331	69	1,644	41,771	1,127
Total ancillary sector	1,940	4,013	545	1,439	221	8,158	196,034	5,786
Total employment	3,737	5,258	1,201	2,550	496	13,242	284,584	7,845

[1] Farm proprietors plus farm wage and salary.
[2] Estimated; the original had been suppressed to avoid disclosures.
[3] Proportion greater than 0.0569 of total employment.
[4] Transportation, communications, and utilities.
[5] Proportion greater than 0.0571 of total employment.
[6] Finance, insurance, and real estate.
[7] Includes other industry wage and salary and nonfarm proprietors.

TABLE II-22.--Employment by broad industry and sector, 1975

[Source: U.S. Department of Commerce, 1977]

	Big Horn County	Custer County	Powder River County	Rosebud County	Treasure County	Montana study area	State of Montana	Sheridan, Wyoming
Basic sector:								
Agriculture[1]	1,020	674	532	649	249	3,124	36,104	874
Mining	269	18	78	393	0	758	6,564	140
Manufacturing	[2]45	116	[2]0	142	0	[2]303	22,996	355
Federal Government	434	365	19	154	7	979	18,934	888
Construction (part)[3]	0	0	0	529	0	529	0	202
TCU[4] (part)[5]	0	59	0	0	10	69	1,048	0
Total economic base	1,768	1,232	629	1,867	266	5,762	85,646	2,459
Ancillary sector:								
Trade	531	1,284	132	426	58	2,431	59,246	1,818
FIRE[6]	82	173	19	[2]53	[2]8	[2]335	9,948	250
Services[7]	[2]792	1,670	261	[2]979	[2]73	3,775	81,197	2,217
Construction (remainder)	177	316	30	243	7	773	12,904	514
TCU[4] (remainder)	113	336	[2]5	218	29	[2]701	18,143	370
Local and State government	572	865	122	493	60	2,112	50,422	1,398
Total ancillary	2,267	4,644	569	2,412	235	10,127	231,860	6,567
Total employment	4,035	5,876	1,198	4,279	501	15,889	317,506	9,026

[1] Farm proprietors plus farm wage and salary.
[2] Estimated; the original had been suppressed to avoid disclosures.
[3] Proportion greater than 0.0569 of total employment.
[4] Transportation, communications, and utilities.
[5] Proportion greater than 0.0571 of total employment.
[6] Finance, insurance, and real estate.
[7] Includes: other industry wage and salary and nonfarm proprietors.

Statewide employment in coal mining has generally decreased since the early part of this century, even though coal production has increased. Until 1923, when Northern Pacific Railroad opened Montana's first strip mine at Colstrip, coal production was primarily from underground mines. Early deep mines typically produced 10 tons per man-shift, while later strip mines could produce 100 tons per man-shift (Morgan, 1966). The greater profitability and safety of strip mining led to a decline in coal mining employment, reaching a low of about 100 workers in 1970. Coal production has increased considerably since 1970, leading to recent increases in total employment in mining. This trend has been moderated by slight increases in worker productivity.

In 1975, total employment in the Montana study area was 15,900 (U.S. Department of Commerce, 1977). The economic base sector accounted for 5,800 (36 percent) of these jobs, while the ancillary (secondary) sector accounted for 10,100 jobs. The base sector was largely composed of agriculture (54 percent of basic employment), Federal Government (17 percent), and construction (9 percent). The largest industries in the ancillary sector were services (37 percent of the sector), trade (24 percent), and local and State government (21 percent). Table II-22 shows the distribution of employment by sector and industry in 1975.

The pattern of employment in the region was reflected in every county except Rosebud, where construction was the second largest basic industry (28 percent of the sector), followed by mining (21 percent) and the Federal Government (8 percent). More than 1,300 people were employed in the construction of Colstrip units 1 and 2 in Rosebud County in 1975.

b. Current trends

Table II-23 illustrates how changes in the basic sector from 1971-75 caused changes in the ancillary sector. Ancillary employment during this period increased by about 1,000, 80 percent of which was due to increases in basic industry employment. The data are aggregated from 14 counties in the Yellowstone Basin, including the EIS region.

TABLE II-23.--Changing employment patterns in Montana counties, 1971-75

	Agricultural	Manufacturing	Mining	Federal Government	Total
Numerical change in employment[1]	-288	-229	1,108	237	828
Employment multipliers[2]	0.804	0.162	0.847	0.874	
Change in ancillary jobs related to change in basic activity	-232	-37	938	207	876

[1]Montana Department of Labor and Industry, 1977.
[2]Centaur Management, 1978.

Basic employment within Sheridan County increased from 1970 to 1975, and ancillary employment increased by about 800 jobs (table II-21, II-22), due to the construction of the Decker mines in Big Horn County, Montana and substantial increases in Federal employment. Almost 9 out of 10 miners at Decker live in Sheridan County and account for some of the increase in ancillary employment.

Coal development in the six-county study area has affected employment and income outside the area, notably in transportation. There are nearly 1,000 people in the Yellowstone Division of Burlington Northern Railroad whose primary job is shipping coal from the area. Other important employment increases have occurred in the industries that produce the machinery used to mine coal. Jobs in industries that consume coal from the area are to some extent attributable to the existing mines and generating units.

c. Unemployment

The Montana portion of the study area has generally experienced an unemployment rate rather lower than the State average during the period 1970-77 (table II-24). Big Horn County, however, had higher unemployment due to the extremely high unemployment rate on the Crow Reservation, which ranged from a low of 27 percent in 1972 to a high of 56 percent in 1977 (U.S. Department of the Interior, 1970-78). Although Rosebud County in general did not exhibit higher than State average unemployment, the Northern Cheyenne Reservation had rates that ranged from a 1973 low of 25 percent to an April 1978 high of 45 percent. Table II-25 shows unemployment rates on the reservations.

TABLE II-24.--Unemployment rates, 1970-77 (percent)

[Sources: Montana Department of Labor and Industry; Employment Security Commission of Wyoming]

	Big Horn County	Custer County	Powder River County	Rosebud County	Treasure County	Montana study area	State of Montana	Sheridan, Wyoming	State of Wyoming
1970--	5.9	4.1	1.8	4.0	4.0	4.4	5.6	4.2	4.4
1971--	7.8	5.0	2.5	3.8	4.3	5.3	6.2	4.1	4.4
1972--	7.7	5.5	2.8	4.1	3.3	5.5	6.1	4.6	4.0
1973--	8.5	4.9	3.0	4.1	3.0	5.5	6.2	4.0	3.4
1974--	9.8	4.5	2.6	4.7	7.0	6.0	6.7	4.1	3.6
1975--	9.1	5.4	3.3	4.3	7.5	5.9	8.1	5.4	4.4
1976--	7.6	4.7	3.2	7.4	5.8	6.2	7.7	4.1	4.1
1977--	7.5	4.8	3.1	5.9	5.0	5.7	6.1	3.7	3.6

TABLE II-25.--Unemployment rates on reservations in the study area, 1971-78 (percent)

[Source: U. S. Department of the Interior, 1970-78]

Year	Northern Cheyenne Reservation	Crow Reservation	All Montana reservations
1971--------	36	32	41
1972--------	27	27	40
1973--------	25	30	39
1974--------	(*)	(*)	(*)
1975--------	40	39	47
1976--------	43	39	44
1977--------	37	56	47
1978--------	45	56	48

*Not available.

2. Income

Montana is primarily an agricultural State, with nearly three-fourths of its land in agricultural production, including forestry. Agriculture's share of total income is four times higher in Montana than in the nation. The study area reflects this dependence on agriculture, but the relative degree of dependence varies from county to county. Despite the importance of agriculture, mining-related jobs have the highest average weekly earnings (table II-26).

TABLE II-26.--Average weekly earnings, September 1978

[Sources: Employment Security Commission of Wyoming, 1978; Montana Department of Labor and Industry, 1978]

Industry	United States	Montana	Wyoming
Farm labor-----	$106.00	$195.00	$155.00
Manufacturing--	255.60	339.07	241.17
Mining---------	344.37	382.39	362.42
Coal mining----	(†)	(†)	409.36
TCU††----------	305.16	311.53	327.02
Trade----------	154.34	170.00	158.46
Retail-------	(†)	(†)	134.72
FIRE*----------	179.82	146.43	(†)
Services-------	165.31	134.73	(†)

†Not available.

††Transportation, communications, and utilities.

*Finance, insurance, and real estate.

In Custer County, direct farm-related income is small compared to income from trade and government, showing the importance of Miles City as a regional trade center. Sheridan County, Wyoming, is also a major trade center for surrounding Wyoming counties, as well as for Big Horn County, Montana. Government and medical services in Sheridan and Miles City serve a wide region. Much of the income in trade, service, and government in these counties is indirectly derived from agriculture.

Rosebud, Big Horn, and Powder River Counties are more directly dependent on agriculture and mining. In Rosebud County, these two activities, along with contract construction related to coal mining, contribute nearly two-thirds of personal income. Government and trade are relatively unimportant as sources of income in Rosebud County, with many services provided out of Billings and Miles City.

Big Horn County depends on coal mining and agriculture and has relatively small trade earnings. County residents travel to Billings and Sheridan for much of their trade and services. Powder River County is in a similar situation, except its mining-related income is largely from oil and gas. Local residents rely more on Miles City and towns in western South Dakota for major purchases and health care.

Treasure County derives nearly two-thirds of its personal income from farming and has very little mining-related income. Hysham, the county seat, is declining in importance as a business center with trade and employment increasingly going to Forsyth and Billings.

In 1969, the most recent year for which county statistics are available, the Montana portion of the study area had a higher proportion of low-income people than the State as a whole. More than one-fourth of all persons had low incomes--that is, they lived in households whose income was less than 125 percent of the poverty level. Big Horn, Rosebud, and Treasure Counties had the highest rates, with more than one-third of all persons having low incomes. About 18 percent of Sheridan County residents had low incomes. All but a small portion of low-income heads of households in the entire study area were older than 65 years, were female heads of household with minor children, or had low-paying full-time jobs, particularly as farm laborers (fig. II-38).

There has not been a substantial improvement in the situation of low-income people in the study area since 1969. Increases in the average income of farm workers has not kept pace with inflation, and there are more persons older than 65. Population growth may well have lowered the proportion of low-income people since 1969, but there are undoubtedly at least as many persons with low incomes.

3. Taxation

a. Sources of revenue

Property taxes bring in most of the revenues to local governments in the study area. Since 1975, three additional sources of revenue based on the contract sales price of coal have been available in Montana.

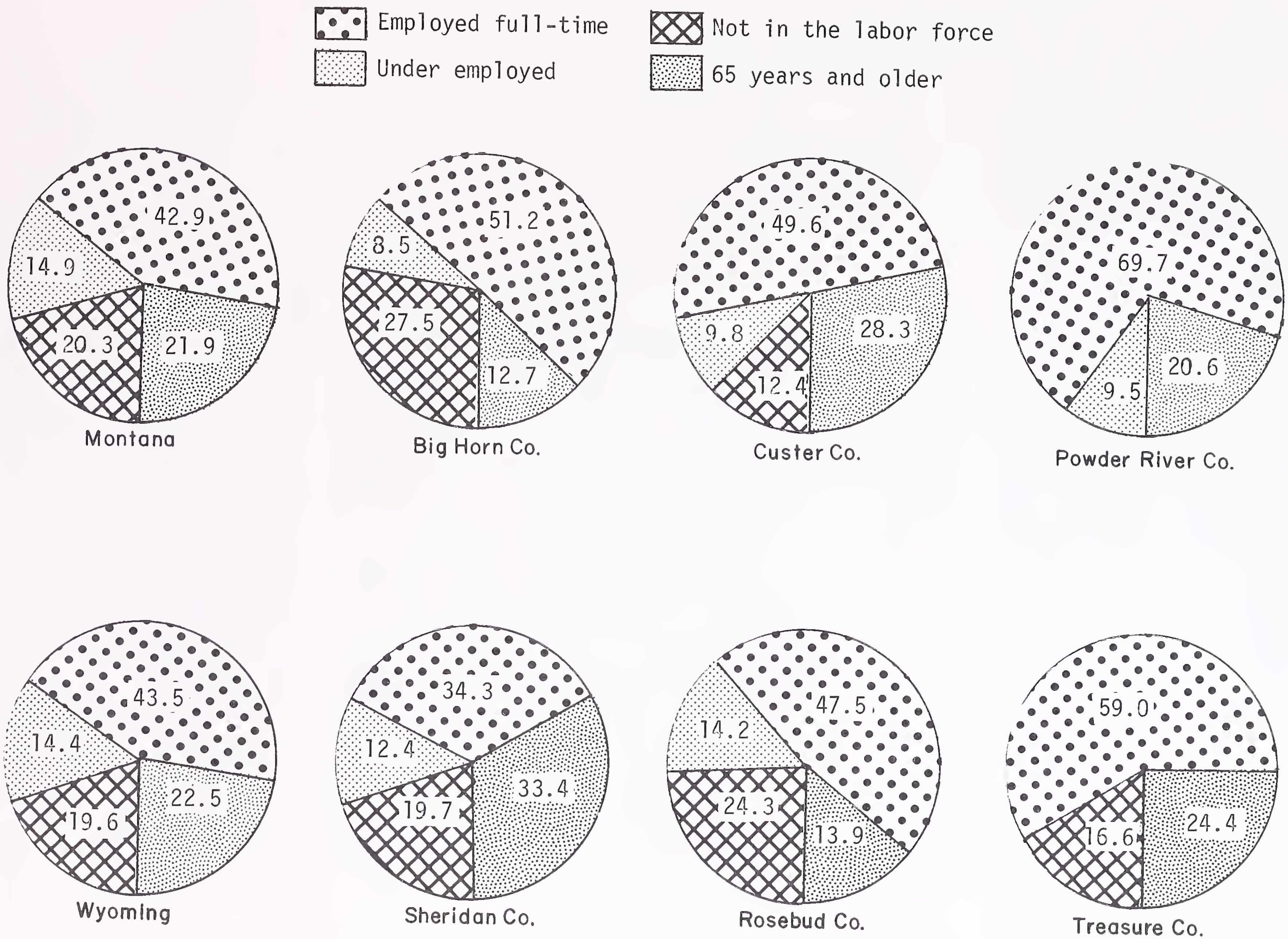


FIGURE II-38.--Characteristics of poverty-level households in the study area, Montana, and Wyoming.

The resource indemnity trust tax (1973) is a fixed percentage of the gross value of the output of any nonrenewable resource including coal. Income from the trust account based on this tax will be available to the State for the first time in 1979. The gross-proceeds tax (1975) is calculated and distributed the same way as property taxes: each local government assesses its mill levy on 45 percent of the contract sales price. The coal severance tax is 30 percent of the contract sales price. The Montana Coal Board, which allocates severance-tax revenues, awarded more than $13 million to impacted communities during fiscal years 1975 to 1977 (table II-27). One of the effects of these taxes is to pass the external costs of coal development on to the users of the coal and compensate future generations for the loss of a nonrenewable resource.

TABLE II-27.--Coal severance tax disposition

[Source: U.S. Community Services Administration, 1975]

Disposition	1977-79 (percent)	1980 and thereafter (percent)
Total severence revenues	100.000	100.000
Coal trust fund	25.000	50.000
State general fund	30.000	19.500
Local impact and education fund	19.875	18.750
School equalization fund of the State	7.500	5.000
Coal highway development program	9.750	.000
Coal-producing counties	1.500	.000
Renewable resource development bond account	1.875	1.250
Alternative energy resource development	1.875	2.500
Park acquisition	1.875	2.500
County planning	.750	.500

[1]The Coal Board awards grants to counties, towns, and school districts which have experienced a 10-percent population increase in a preceding 3-year period due to coal development. The grants are made from the 19.875 percent set aside for the local impact and education trust account (18.750 percent 1980 and thereafter). Awards are judged on need, severity of impact, availability of funds, and local effort.

The disposition of severance tax receipts is subject to change. A 1976 constitutional amendment was approved by voters to place at least

a fourth of the proceeds into a coal severance trust fund. After December 31, 1979, at least 50 percent will be dedicated to the trust fund. The principal of the trust fund can be appropriated only by a three-fourths vote of members of each house of the legislature. Interest and income can be appropriated.

1) Montana counties

Property taxes are the main source of county revenues in Montana. In 1976, 22.5 percent of Montana's property-tax revenues was allocated to counties (Montana Department of Revenue, 1977). The gross proceeds tax has become an increasingly important revenue source. For example, in 1970 there was no tax revenue from coal production in Big Horn County, while in 1976, the gross proceeds tax contributed over 60 percent of the county's taxable value.

Montana counties also receive revenue from automobile registrations, fees, licenses, fines, land rentals and royalties, in-lieu payments, and State and Federal grants.

2) Montana school districts

Over the past 20 years education has become the highest local government expenditure in Montana. Montana schools are financed largely through revenues from property taxes. A school equalization fund established in 1973 requires counties to impose a 40-mill levy. If that levy raises more than the county school program requires, the surplus goes to the State to be redistributed to needy counties. Revenues from the equalization fund are for operating expenses only; expansion of school facilities must be financed by permissive and voted levies, school board bond issues within each school district, or from outside sources.

3) Montana towns

Property taxes are the single most important revenue source for incorporated cities and towns in Montana. However, a substantial amount is collected from licenses, fines, permits, and user fees for water, sewage, and garbage services. Federal revenue sharing became an important source of funds to cities and towns in the 1970's.

4) Wyoming counties

Sources of revenue for county budgets include taxes on sales, gasoline, cigarettes, and property; licences, fees, and royalties; miscellaneous taxes, plus revenue sharing and grants from the State. Wyoming, unlike Montana, has a State sales tax; it is a very important revenue source. Of the 1975-76 total State tax collections ($333,750,000) 22 percent came from the sales tax. The sales tax rate can vary among the counties because each county can choose to impose an additional 1-percent tax on sales within their boundary. Sheridan County adopted the additional 1-percent tax in 1978 raising the tax rate to 4 percent. The gross-proceeds, resource indemnity trust, and severance taxes from mines in Montana would not normally contribute revenues to impacted local Wyoming governments.

5) Wyoming school districts

The primary source of school funding is property tax: 75 percent of all property taxes raised in Wyoming is used for schools. Since approximately half of the property base in Wyoming is supported by mineral revenues, the financial capacities of school districts vary greatly according to mine locations. Sheridan school districts have low assessed valuations, and are poor relative to other school districts in Wyoming.

Wyoming schools also receive funds from school lands income, oil royalties, vehicle registration fees, and general State appropriations.

6) Wyoming towns

Revenues come from practically the same sources as for Wyoming counties.

b. Revenue trends

Revenues from taxes in the study area generally increased steadily until the late 1960's, but only slightly when adjusted for inflation. In the late 1960's and early 1970's, however, tax revenues increased significantly. This was due to the increased value of taxable property from coal, gas, and oil development in the region (table II-28), and from the gross-proceeds, severance, and resource indemnity trust taxes.

1) Montana counties

County revenues increased with recent energy development, largely because of the increase in the value of taxable property. Taxable property value increased in Powder River County, because of increased oil production; in Big Horn and Rosebud Counties, mainly because of Colstrip units 1 and 2, new strip-mining equipment, and the gross-proceeds tax on coal sales. Taxable value in Treasure County increased far less than in the other counties in the study area. The increase in the value of taxable property made it possible for the other counties to reduce their mill levies. Thus, the fiscal 1977 levy for Big Horn County was 15 mills, for Rosebud County 22 mills, while the average levy for Montana counties was 52 mills.

2) Montana school districts

Similarly, tax revenues increased greatly with the substantial increases in taxable valuation in 10 of the 25 school districts in Big Horn, Rosebud, and Treasure Counties (Robinson, 1977). Coal development and the gross-proceeds tax accounted for most of the increase. Accordingly, total mill levies for most of these school districts were reduced. Generally, except for the Ashland, Forsyth, and Rosebud elementary-school districts, the Montana school districts in the study area have been better able to meet their expenses than other districts with similar

TABLE II-28.--Fiscal trends for Montana counties in the study area (1967 constant dollars)[1]

[Source: Montana Department of Revenue, 1945-76]

	Tax revenues[2]					
	Big Horn County			Powder River County		
Year	County	School district	Town	County	School district	Town
1946---	$394,382	$311,873	$68,950	$125,363	$107,659	$7,668
1951---	453,638	538,784	118,668	130,973	135,224	17,523
1956---	477,277	604,124	152,782	152,278	178,187	17,955
1961---	460,669	750,385	157,315	197,479	210,738	25,359
1966---	447,937	701,920	171,132	207,940	299,010	26,767
1971---	674,724	932,215	160,400	467,940	730,191	34,458
1976---	727,014	1,640,839	219,795	1,172,756	2,171,983	34,350
	Treasure County			Rosebud County		
Year	County	School district	Town	County	School district	Town
1946---	$81,326	$97,382	$8,063	$408,829	$316,398	$44,239
1951---	81,713	104,354	10,209	426,367	383,273	61,458
1956---	91,359	116,975	15,616	505,571	476,276	69,812
1961---	83,672	119,869	16,041	596,305	550,025	66,719
1966---	88,988	141,639	13,177	665,394	550,988	67,576
1971---	84,245	174,673	30,317	673,638	704,534	85,347
1976---	87,843	146,322	21,740	1,414,985	2,333,960	155,260

[1]U.S. Department of Labor, Consumer Price Index.
[2]Total amount of taxes levied.

enrollments. But property taxes from mines have directly benefited only the school districts that include those mines. School districts in which property-tax revenues have not kept pace with expenses due to energy development have had to depend on grants from the State Coal Board for financial support (table II-29).

3) Montana towns

For some towns in the study area, expenses increased faster than revenues, because mines are generally outside municipal tax boundaries, and the value of taxable property within those boundaries did not increase enough to meet expenses due to population increases induced by mining. In Forsyth, for example, property-tax rates in 1976 were the highest ever (table II-30), even though the corresponding Rosebud County tax rates were the lowest in 12 years. Of the 46 Montana towns with 1970 populations between 1,000 and 5,000, Forsyth had the 13th highest

TABLE II-29.--Coal Board allocations as of October 13, 1978

[Source: Montana Department of Community Affairs, 1978]

Project	Amount allocated
Ashland Public School (3/77)	$800,000
Ashland water and sewer (3/77)	71,080
Ashland Volunteer Fire Dept. (10/77)	45,000
Big Horn County Courthouse/ law enforcement (11/77)	416,000
Big Horn County rural fire equipment (10/78)	75,000
Colstrip[1] water treatment system (12/76)	656,600
Colstrip Elementary School (3/77)	449,921
Colstrip High School (3/77)	317,185
Colstrip[1] sewage treatment (6/77)	538,000
Colstrip school equipment (6/77)	100,000
Colstrip[1] street cleaning and fire equipment	83,000
Colstrip Elementary School equipment (12/77)	38,544
Colstrip community services facility (10/78)	300,000
Custer County water and sewer district (9/78)	358,000
Dawson County census (1/77)	11,500
Forsyth High School (7/76)	27,000
Forsyth water treatment distribution and storage (7/76)	615,000
Forsyth capital equipment (9/76)	154,682
Forsyth Elementary School (12/76)	2,500,000
Forsyth municipal water distribution mains	87,000
Forsyth capital equipment #2 (5/77)	58,500
Forsyth sewage collection, treatment, and disposal (5/77)	25,000
Forsyth solid waste system improvements (7/77)	145,000
Forsyth wastewater pumping station (8/77)	150,000
Forsyth Elementary and High School equipment and construction (partial)(5/78)	193,230
Hardin sewer lagoon (6/76)	231,135
Hardin capital equipment (7/76)	128,154
Hardin Elementary School (1/77)	2,041,648
Hardin High School (1/77)	1,168,000
Hardin sewer trunk main (6/77)	416,978
Hardin water system improvements (8/77)	260,900
Hardin capital equipment (9/78)	57,388

See footnote at end of table on p. II-99.

TABLE II-29.--Coal Board allocations--Continued

Project	Amount allocated
Hysham water distribution system (3/77)--------	$388,440
Hysham sewer system (6/77)---------------------	56,500
Hysham capital equipment (9/78)----------------	50,000
Laurel water treatment (9/78)------------------	483,722
Lodge Grass capital equipment (7/76)-----------	125,250
Lodge Grass water line (12/76)-----------------	171,872
Lodge Grass capital equipment (9/77)-----------	60,619
McCone County Planning (6/77)------------------	42,500
Miles City Community College (11/77)-----------	1,529,663
Rosebud County Planning (9/76)-----------------	32,000
Rosebud County Jail (11/76)--------------------	100,000
Rosebud School District (12/76)----------------	465,000
Rosebud County water and sewer district (6/77)-	51,000
Sagebrush Library Federation (10/76)-----------	61,100
16th Judicial District (7/76)------------------	29,000
Treasure County health nurse (12/76)-----------	4,490
Treasure County patrol car (6/77)--------------	7,768
Treasure County Planning (9/78)----------------	17,000
Tri-county solid waste disposal (2/78)---------	289,859

[1]The grants to Colstrip were possible because of the creation of rural improvement districts. Colstrip is an unincorporated town and, as such, is not eligible for State grants. The Colstrip School District is considered a governmental entity and is eligible for Coal Board grants.

property-tax rates in 1976. Despite the high tax rate, Forsyth's property-tax revenues were insufficient to meet expenses. Forsyth, Hardin, Hysham, and Lodge Grass have all had to depend on Coal Board grants and other outside revenues to meet their expenses (table II-29) (Robinson, 1977).

4) Sheridan County

Assessed valuation and mill levies in Sheridan County have increased in the past few years (table II-31). The total maximum levy for the general fund cannot exceed 12 mills except for the financing of its

TABLE II-30.--City mill levies,[1] Montana

[Source: Montana Department of Revenue, 1945-76]

County---	Rosebud	Powder River	Big Horn
Town-----	Forsyth	Broadus	Hardin
Year			
1962-63---	38	39.5	49.5
1963-64---	38	40.5	49.3
1964-65---	38	43.5	43.6
1965-66---	38	46.5	46.5
1966-67---	38	46	43.2
1967-68---	43	48	43.5
1968-69---	43	47	42.5
1969-70---	43	46	48.8
1970-71---	47	58.5	51.4
1971-72---	48	66	49.7
1972-73---	48	75.5	51.1
1973-74---	55	75.5	57.3
1974-75---	55	65	62.5
1975-76---	69	63	67.5
1976-77---	69	64	67.5

[1]These include the all purpose city mill rate which cannot exceed 65 mills plus the levies necessary to service bonded indebtedness or special district revolving funds.

TABLE II-31.--Assessed valuation and mill levies in Sheridan County, Wyoming

	1974	1975	1976	1977	1978
Assessed valuation (millions of dollars)---	45.6	47.0	54.2	47.7	84.7
Mill levy (mills)-----------------	11.5	12	12.8	14.14	14.6

public debt; however, additional mills can be levied for special districts and other purposes (L. Thompson, 1977).

5) Sheridan County school districts

School District No. 1 has a fiscal crisis (Thompson and others, 1978) because its two new elementary schools have exhausted its bonding capacity. School District No. 2 has no present fiscal problems, because it includes the city of Sheridan, and the district's assessed valuation has increased

commensurately with its expenses due to population increases. District No. 3 is not growing, and no impacts are expected there.

6) City of Sheridan

From 1974 to 1978, assessed valuation in Sheridan increased from $18 million to $23 million, and mill levies were reduced from 12.9 to 10.9 mills (table II-32). Total mill levy for the city general fund cannot exceed 8 mills except for financing its public debt. Additional mills can be levied for other purposes. Sheridan's revenues have been adequate to meet its expenses in recent years, but it may not be maintaining the quality of its community services. (See Community Services, chapter IV.)

TABLE II-32.--Assessed valuation and mill levies in Sheridan, Wyoming

	1974	1975	1976	1977	1978
Assessed valuation (millions of dollars)--	17.6	18.1	21.7	23.4	23.9
Mill levy (mills)----------------	12.9	15.1	11.7	11.5	10.93

4. Trade

Agriculture, trade and services, and mining dominate business activity in Montana and Wyoming. Major trade centers for the study area include Billings, Miles City, and Sheridan. The towns of Forsyth, Hardin, Broadus, and Hysham serve as minor trade centers, primarily for convenience items. The income and employment sections discuss the relative importance of these trade centers in more detail.

a. Nature of secondary trade

Table II-33 shows retail sales in Montana by product line for 1972. Of these industries and businesses, only building materials and eating and drinking places manufacture any significant part of their product within Montana. Although Montana is a major agricultural and crude oil producer, it is importing its food and fuels. Montana refineries import over 80 percent of their crude oil (primarily from Canada), while Montana beef and wheat is sent out of the State for packing and grinding to flour. Even the grains fed to cattle in the State are mixed by firms outside the State. Most of the cost of cattle feed from grain grown in Montana comes from transportation and value added in the finishing activity.

TABLE II-33.--Number of firms and sales volume by product (Montana)

[Source: U.S. Department of Commerce, 1974]

Product line	Sales (thousands of dollars)	Percent of total[1]	Number of firms	Percent of total[1]
Building materials	137,812	9	516	6
General merchandise	140,636	9	240	3
Food stores	357,938	22	952	11
Autos	340,112	21	577	7
Gasoline and related	150,242	9	1,190	13
Furniture	65,012	4	396	4
Eating/drinking places	153,428	10	2,111	24
Drug stores	56,750	4	222	2.5
Miscellaneous	130,849	8	2,146	24

[1]Totals do not add to 100 due to rounding.

b. Net trade flows

Income generated within the region is primarily spent on goods produced outside the region. Nearly three-fourths of the retail goods sold in the region in the early 1970's were imported. The region's major employers either produced no goods (such as the Federal Government), or produced goods more for export than for local consumption. In the early 1970's, 98 percent of the coal, at least 80 percent of agricultural production, and about 90 percent of the oil produced in the region was exported.

c. Net capital flows

Montana's financial centers are currently unable to provide the money needed to finance business, government, and personal borrowing. Forty-three percent of the total loan capital imported into the State from 1967 to 1977 was used to finance agriculture and mining. About $1 billion was imported for agriculture during this period, and new mining accounted for another $200 million. Commercial trade firms, such as national chain stores, also used money markets outside the State for more than half of their capital.

d. Trade and capital flow on the reservations

The economies of the Crow and Northern Cheyenne Reservations depend even more heavily than the rest of the region on the export of raw materials, and they are even less able to attract or retain capital. So long as this pattern does not change, Indians will continue to leave the reservations for major medical care, continued education, jobs, and purchase of goods and services. This pattern will probably not change

much in the near future, because the strong cultural traditions of the tribes and tribal laws and policies tend to inhibit such changes.

There are no conversion facilities for raw materials, mainly agricultural products and coal, on the reservations. These products are almost entirely exported, but they account for practically the only non-governmental wages made on the reservations. There is only one manufacturing firm on the reservations, so almost all manufactured goods are imported, and almost all wages and profits from manufacturing are made off the reservations.

There are no banks on the reservations, so all capital for loans is imported. There are no large trade centers, so most wages and profits for goods and services also are made off the reservations, and those on the reservations are commonly not made by the Indians.

This pattern might change if the Crow successfully negotiate agreements with the major coal companies to assure them of a share of mining jobs and to provide for royalty payments, which would provide capital for diversifying the Crow economy. Even so, the Crow will continue to spend most of their incomes off the reservation so long as trade centers don't grow above the present stage.

Similarly, employment and business patterns on the Northern Cheyenne Reservation will be even less likely to change in the near future. This is so for two reasons: (1) mining and power-generating plants are effectively excluded from the reservation because its air quality was designated Class I, at the tribe's request; (2) there won't be much mining for a decade or more, because the Supreme Court awarded the tribe the right to cancel all existing mineral leases and to control all mineral rights on the reservations.

J. COMMUNITY SERVICES

The following discussion is based on information in four reports provided under contract to the Department of State Lands and the U.S. Geological Survey--Meadowlark (1978), the University of Wyoming (1978; 1979), and McQuiston (1979).

1. Welfare Agencies

Welfare services are provided in Montana by the Division of Social and Rehabilitation Services (SRS), and in Wyoming, by the Department of Public Assistance and Social Services (DPASS). In Wyoming, welfare services are funded by the State; in Montana, by the counties and the State. In the judgement of their managers, offices in Sheridan and Custer Counties do not have enough personnel. The Custer County office in Miles City is staffed at only 60 percent of its authorized level. The Big Horn County Welfare Office lacks the funds to provide all required services adequately. Rosebud County appears to be adequately staffed with full-time offices at Lame Deer and Forsyth.

Table II-34 compares existing space and staffing with what is needed to provide adequate welfare services. Judgements of adequacy and need were based on the assumption of 16 to 17 cases per caseworker.

TABLE II-34.--Personnel and square footage analysis

	Number of personnel		Square footage	
	Actual	Adequate	Actual	Adequate
Lame Deer-----	5	5	400	1,600
Forsyth-------	6	6	2,584	1,800
Miles City----	9	12	1,572	3,000
Hardin--------	9	9		2,400
Sheridan------	10	16		4,000

2. Public Health

Health service in the study area is generally good, but people in remote areas often find it difficult to use existing services. There are problems finding enough physicians to staff the small hospitals at Forsyth and Hardin, and often there are not enough volunteers to assist with ambulance and other emergency services throughout the study area.

Hospital beds appear to be adequate for the regional population, but they are poorly distributed. Hospitals in Miles City and Sheridan are adequate to serve their respective counties, but the hospital at Miles City also serves many people in Powder River, Rosebud, and Prairie Counties. Veterans hospitals in these two towns provide specialists for consultation but do not serve the county populations. The understaffed hospitals in Forsyth and Hardin do not adequately serve county populations, and many people travel instead to larger hospitals in Miles City, Billings, or Sheridan. Table II-35 shows the size and staffing of hospitals in the study area.

Big Horn and Rosebud Counties are critically understaffed with physicians--about one-fourth the national average per 1,000 population (table II-36). Sheridan and Custer Counties probably have sufficient primary care physicians, even though they fall somewhat below the national average. The shortage is mainly in specialists; doctors in these two counties often send their patients to specialists in Billings or Denver.

Public health nurses provide many medical services in all six counties. In Big Horn County, community health medics are certified to help Crow tribal members. Public health nurses are funded by the counties.

Ambulance services in the study area are run by volunteer and paid employees. Most of the counties provide the vehicles and equipment. Ambulance technicians and drivers in Custer County are firemen provided by Miles City. Ambulance services in Big Horn County have full-time paid

TABLE II-35.--Hospital staffing and bed ratios

County	Name of hospital	Number of beds	Beds/ 1,000	Percent national adequacy standard	Number of staff[2]
Big Horn-------	County Memorial	16[1]	2.8	70	50
	Indian Hospital	34	6.8	170	96
Custer---------	Holy Rosary	120	10	250	194
Rosebud--------	Rosebud Community	18[1]	1.7	42.5	65-70
Sheridan-------	Sheridan Memorial	97	4.34	108.5	97

[1]Both Rosebud and Big Horn County Hospitals have extended care (nursing home) facilities and both have had overflows from these facilities into General Hospital beds. Because of this, Rosebud County has set aside 8 of its 26 beds for nursing home use.

[2]Full time equivalents--estimated for Rosebud County.

TABLE II-36.--Physician distribution by county[1]

County	Number of physicians	Rate per 1,000 of population	Percent of adequacy
Custer-----------	20	1.563	85
Big Horn:			
Private--------	2	.35	20
Indian---------	5	1.0	54
Rosebud----------	3	.316	18
Sheridan---------	31	1.387	76
Region total---	62	1.0	60

[1]Centaur Management, Socio Economic Study of Lower Yellowstone Area, July 1978.

employees and are supplemented by volunteers. Ambulance crews in Rosebud County are trained volunteers with some funding from Western Energy Company. Sheridan County has ambulance service provided by two private mortuaries. City firemen trained as emergency medical technicians often respond to calls. Service is rated excellent, but there are not enough trained volunteers and maintenance money to provide sufficient service.

Miles City has a charter air ambulance to Billings, and Sheridan has two charter air ambulances. Hospitals in Billings and Denver can also fly crews and planes to the study area to pick up patients.

Mental health and drug abuse programs in the study area are generally understaffed and underfunded, due mostly to the large areas they must serve.

Sheridan is one of seven Wyoming counties covered by the Northeast Wyoming Mental Health Center. Custer County's Mental Health Center covers 17 counties, including Powder River and Rosebud, while Big Horn is served by the center at Billings. Hardin and Forsyth also are served by full-time caseworkers. There is no clear-cut responsibility for funding these centers, and some counties shirk their share of the load. The large areas covered mean that professionals must spend some 10 percent of their time traveling. Drug abuse programs are provided by the regional mental health centers; Rosebud, Big Horn, Sheridan, and Custer Counties have their own full facilities. Table II-37 shows additional staff and space needs for mental health programs in the study area.

TABLE II-37.--Current mental health personnel needs in the study area

	Miles City[1]		Sheridan[2]		Billings[3]	
	Number of people needed	Additional square footage required	Number of people needed	Additional square footage required	Number of people needed	Additional square footage required
Administration and support----	1	200	1	200	---	---
Psychiatrist and other professionals--------	2	500	1	250	1	250
Paraprofessionals	2	500	1	250	---	---

[1]Personnel needs are only for Rosebud, Powder River and Custer Counties. Other counties have additional needs, but they are not shown.

[2]Personnel needs are only for Sheridan County.

[3]Personnel needs shown are only for Big Horn and Treasure Counties. Other counties served by this center also have additional needs, but they are not shown.

3. Law and Equity

The criminal justice system in the study area is not efficient. Professionals interviewed said that broad reforms are needed, particularly to improve jails and ease delays in criminal proceedings. Crime rates are in the normal range for rural counties.

Only one of ten jails in the area meets constitutional requirements. The other nine could be closed at any time upon a court finding that inmate rights are being violated.

Trials are slow because there are too few county attorneys and district judges. Decisions are being reversed because of slow trials. One county has no staff attorney, and several have part-time attorneys.

Due to the large areas covered by district judges, cases often must be tried outside the county in which the offense occurred. This leads to lost time in travel and to reluctant witnesses. Breakdowns in the criminal justice system may also be due, in part, to increased civil action caseloads. The low pay of police officers means that many are attracted to higher paying jobs and dedicated officers who remain sometimes neglect additional training for casework. Law officers have complained of poor follow-up on their arrests.

Tables II-38 and II-39 show crime rates and numbers of law enforcement officers in the study area. Due to the small size of the counties, crime rates and numbers of officers per 1,000 population are not comparable with more populous areas. Similarly, in counties with small population, several years may elapse between violent crimes, making the average for any one year unusually low or high.

TABLE II-38.--County crime rates by type of crime, 1976

[Sources: Montana statistics--Centaur Management, May 1978; Sheridan statistics--1976 Uniform Crime Report, Federal Bureau of Investigation]

	Homicide	Assault	Robbery	Rape	Vehicle theft	Larceny theft	Burglary
Big Horn	0	122	0	37	103	412	562
Custer	23	54	31	8	315	1,461	600
Rosebud	0	658	0	52	261	1,242	898
Sheridan	9	103	14	5	132	2,134	277
Montana	5.4	151	37.6	16.5	309	2,863	886

TABLE II-39.--Number of sworn officers by area

County	Type of force	Line officers	Support persons	Officers per 1,000 people
Big Horn	Consolidated[1]	12	4	2.0
	Crow force	6	8	1.2
Custer	Miles City Police	15	5	1.6
	Custer County Sheriff	4		1.2
Rosebud	Consolidated[1]	14	4	2.1
	Cheyenne force	8	1	3.5
Sheridan	City police	28	13	1.8
	County Sheriff	6	3	.9
U.S.		418,000	---	2.1

[1]The consolidated forces serve all areas within a county (including cities and rural areas) except for the Cheyenne and Crow Reservations in Big Horn and Rosebud Counties.

4. Cultural Opportunities

Club- and church-centered activities dominate cultural life in the study area (Uhlmann, 1977; Centaur Management, 1978). When the church or club activity is not in itself the event (such as at county fairs), these units are the social group which attend the event.

There are community libraries in Miles City (102,000 volumes), Sheridan (45,000 volumes), Forsyth (20,000 volumes), Broadus, and Hardin. Ranchester, Clearmont, and Story have branches of the Sheridan library. The Sagebrush Federation of Libraries operates a bookmobile service to Hysham, Colstrip, and other rural communities. Librarians interviewed felt that there is adequate space and staff to serve the existing population.

5. Fire Protection

Towns in the study area generally have adequate fire protection. Service in rural areas is limited and usually consists of associations attached to the county sheriff's offices or services contracted with fire departments in towns. Sheridan County, the city of Sheridan, and rural areas of Rosebud County, however, have inadequate protection.

In Rosebud County the Forsyth, Colstrip, and Ashland Fire Districts are all providing adequate protection to their respective areas. Forsyth has recently installed a new water storage facility, bringing its water delivery system above sufficient standards. The Colstrip District has contracts for fire protection with several companies and businesses in addition to the area within its boundaries. The district's fire department and dispatch center will be housed in the Colstrip Community Service building now under construction. Most volunteers in Colstrip are on shift work and not all are able to respond at the same time to a fire. Ashland has a new fire district with a new station and may soon expand to cover parts of Powder River County. Almost all of rural Rosebud County is unprotected and bears the most expensive insurance rating, Class 10.

The Big Horn County Fire Department operates under the sheriff and serves the rural areas of the county. Its firemen consist of county work crews and deputies. Two new fire trucks were obtained using Coal Board funds. The Hardin Fire Department provides adequate protection, although the water supply is limited during large fires. The city is asked to cut water use during large fires. The department operates on 1 mill of city taxes and can increase 1 mill for additional funding.

Fire protection in Custer, Powder River, and Treasure Counties is generally adequate, although Miles City and Broadus plan to make improvements to lower their fire insurance ratings.

Sheridan County's Fire Department operates out of the city airport and is supplemented by five rural volunteer districts. Recent population growth has created a need for about twice the present manpower and equipment

and a new fire station north of Sheridan. The county sometimes receives two calls at the same time and is unable to repond properly to both. The city of Sheridan needs to double its personnel to meet State standards and needs an additional pumper and pickup truck.

6. Education

Schools are generally adequate for the existing population in most of the study area. The Hardin High School has more space than is needed, a costly condition for the district. School District 1 in northern Sheridan County has recently added new elementary schools in Big Horn and Ranchester, but population increases are already meeting or exceeding the capacity of these schools.

School districts throughout the study area have difficulty recruiting and keeping teachers, particularly in rural areas. Special education programs in many districts are underfunded. Schools in the city of Sheridan have recently been expanded and can accommodate some additional increase in population. The city's school district is at its maximum bonding capacity, but this capacity will increase somewhat due to increasing assessed valuation.

7. Housing, Water, Sewer, and Solid Waste Service

The only major physical limitation on new housing in the study area is the capacity of water and sewer systems. Forsyth, Hardin, Miles City, and rural communities in northern Sheridan County all have limited ability to provide new water and sewer service. Coal development has compounded housing problems in Forsyth and Sheridan by increasing demand and helping drive up prices. Low income housing is scarce and usually in poor condition, particularly in Sheridan. Inflation and high interest rates also contribute to this problem.

The communities in Montana which are expected to receive most of the coal-related growth generally have adequate water, sewer, and solid waste systems. Some improvements are planned which should increase capacities, including new solid waste canisters in rural areas. Hardin's sewage system is near capacity, but the city is anticipating the need to expand its trunk lines and sewage treatment plant. Forsyth's sewage system is also near capacity, but there are evidently no plans for expansion. Colstrip and Ashland have excess water and sewer capacities which are somewhat of a financial burden.

There are no water or sewer facilities in the rural areas or unincorporated towns in Sheridan County. Many new housing developments do not have adequate sources of ground water, and soils are not appropriate for septic tanks in some areas. Solid waste disposal has not yet become a major problem.

The city of Sheridan's water system can supply up to 20,000 people, more than enough for its current population. The treatment plant is closer to capacity than the supply and distribution system. Sheridan's

sewage treatment plant is at capacity and is now overloading Goose Creek. Further growth would cause more deterioration in water quality. Sheridan may soon receive an EPA grant to plan and design a new sewage treatment plant. The city's sanitation system is apparently adequate, although there is a problem with employee turnover due to relatively low pay.

K. LAND OWNERSHIP AND LAND USE

1. Land Ownership

About three-fourths of the land (surface estate) in the designated region is privately owned; over half of the mineral rights (subsurface estate) remains in Federal ownership (figs. II-5, II-39). The same general pattern exists in the three-county study area (Big Horn, Rosebud, and Sheridan Counties) with the exception of Indian lands. Impacts on land ownership and use would generally be limited to this study area.

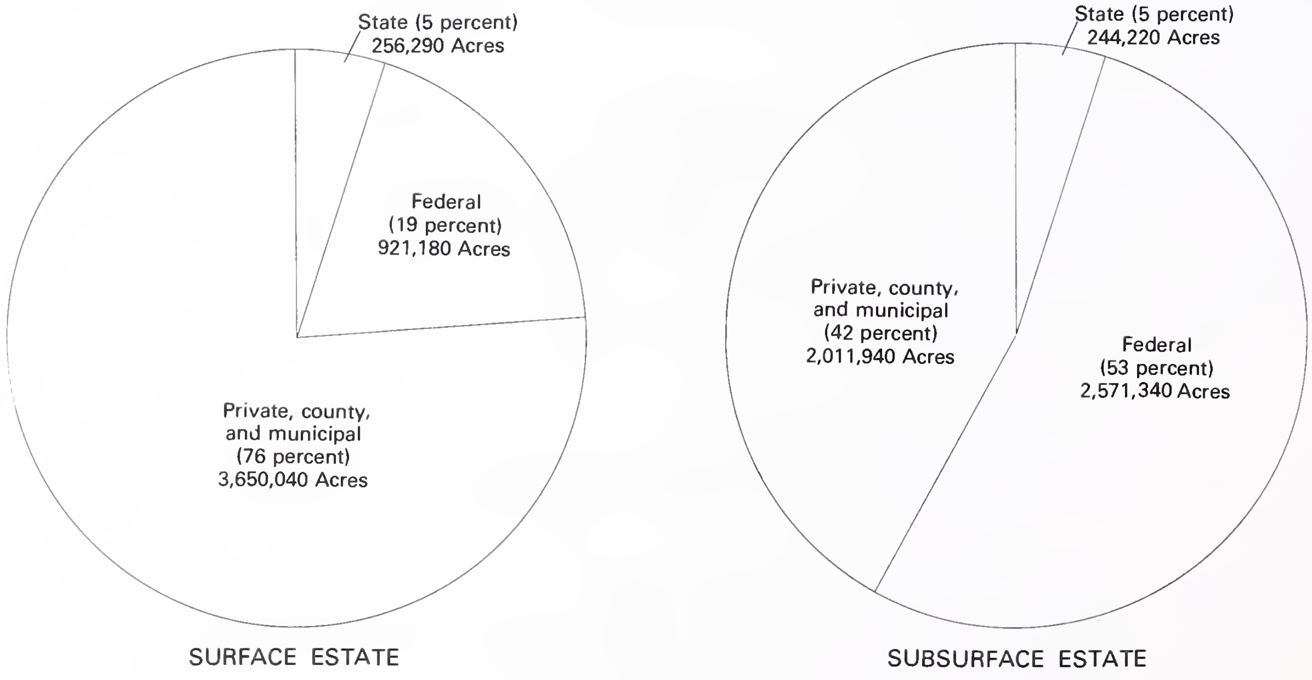


FIGURE II-39.--Surface and subsurface ownership in the designated region.

The Crow and Northern Cheyenne Indian Reservations lie just west of the designated region. They are not included in the designated region because land ownership and administration on the reservations is subject to different policies and regulations. About 69 percent of the land on the Crow Reservation is in tribal or trust ownership; non-Indians own about 31 percent. About 98 percent of the Northern Cheyenne Reservation is Indian-owned.

In the Crow Ceded Area, which also lies west of the designated region, about 150,000 acres of subsurface coal rights is held in trust for the Crow Indians by the Secretary of the Interior. Of the surface ownership, more than 1 million acres is private, 45,000 acres is State, and 26,000 acres is tribal or allotted.

2. Land Use

Figures II-40 and II-41 show generalized land use near the proposed mines. Although not prime agricultural land, most of the study area is used for agriculture, mainly as rangeland. Dry croplands, managed pasture, hay fields, and pastured woodlands are locally important. Irrigated lands--primarily along the Yellowstone, Tongue, and Powder Rivers--are particularly important in providing winter feed for the region's dominant livestock industry.

The areas proposed for mining are used mainly as rangeland. They include no irrigated lands. None of the area have been designed unsuitable for mining under the provisions of the Surface Mining Control and Reclamation Act. Tables II-40 and II-41 identify farm lands in the three-county study area. For the "farm operating units" that were inventoried, about 91 percent of the study area is used mainly for grazing. Dry cropland makes up about 6 percent of the study area and irrigated cropland about 1 percent. Lands in the study area not covered by the agricultural census (11 percent) are mostly public lands used for grazing by permit from the U.S. Forest Service, BLM, or the Montana Department of State Lands. These lands are also used for recreation, timber sales, watershed, and wildlife, or leased for oil and gas production.

TABLE II-40.--Farm lands, 1974*

[Source: U.S. Department of Commerce, Bureau of Census, Agricultural Census, 1974]

County	Total area (acres)	Farms: Total number	Farms: Total acreage	Farms: Percentage of county land	Farms: Average size of farm (acres)
Big Horn--------	3,214,720	508	2,647,912	82.4	5,212
Rosebud---------	3,223,424	342	3,009,037	93.3	8,798
Sheridan, Wyo.----------	1,620,480	456	1,471,272	90.8	3,226

*The Agricultural Census includes only land within farm operating units. It thus excludes lands in urban, industrial, transportation, or similar uses and lands grazed under Government permit.

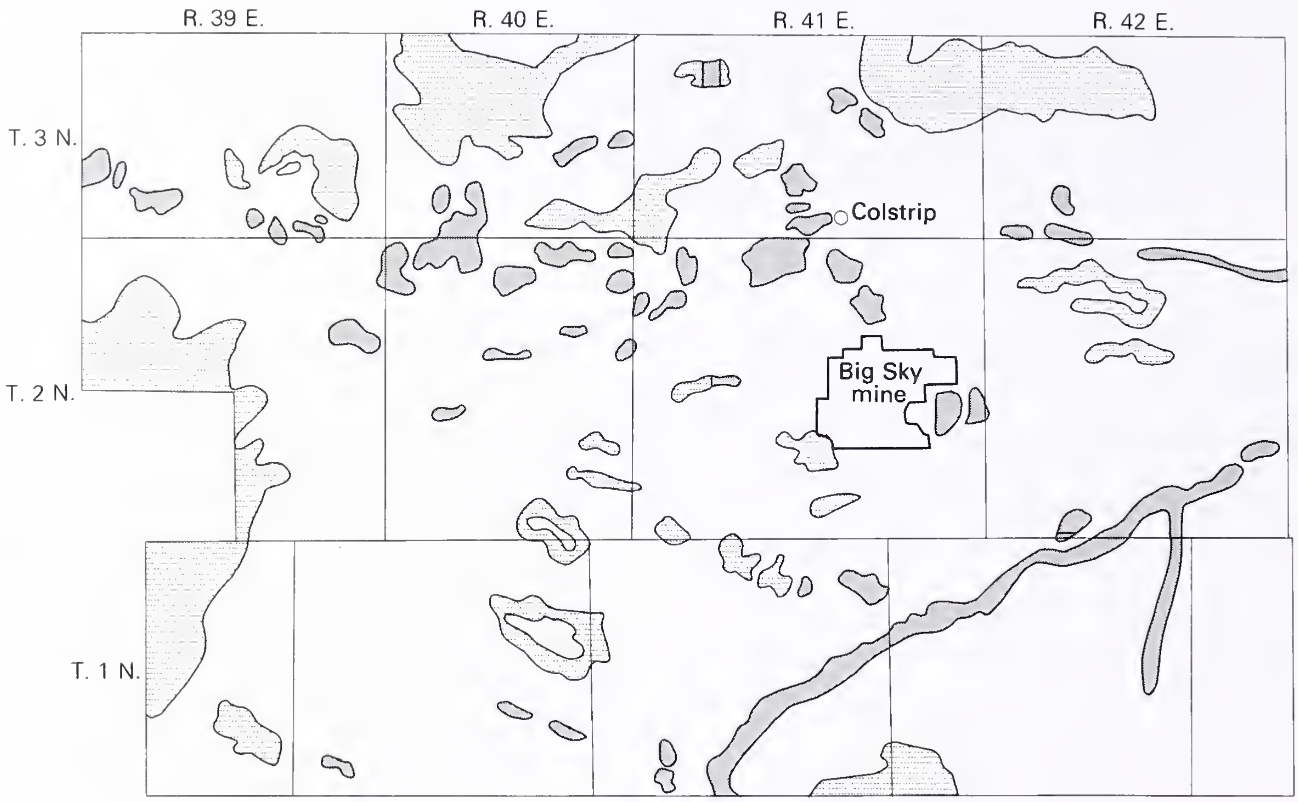


FIGURE II-40.--Land use in the Colstrip subregion. Map prepared by the Yellowstone-Tongue Areawide Planning Organization, 1977.

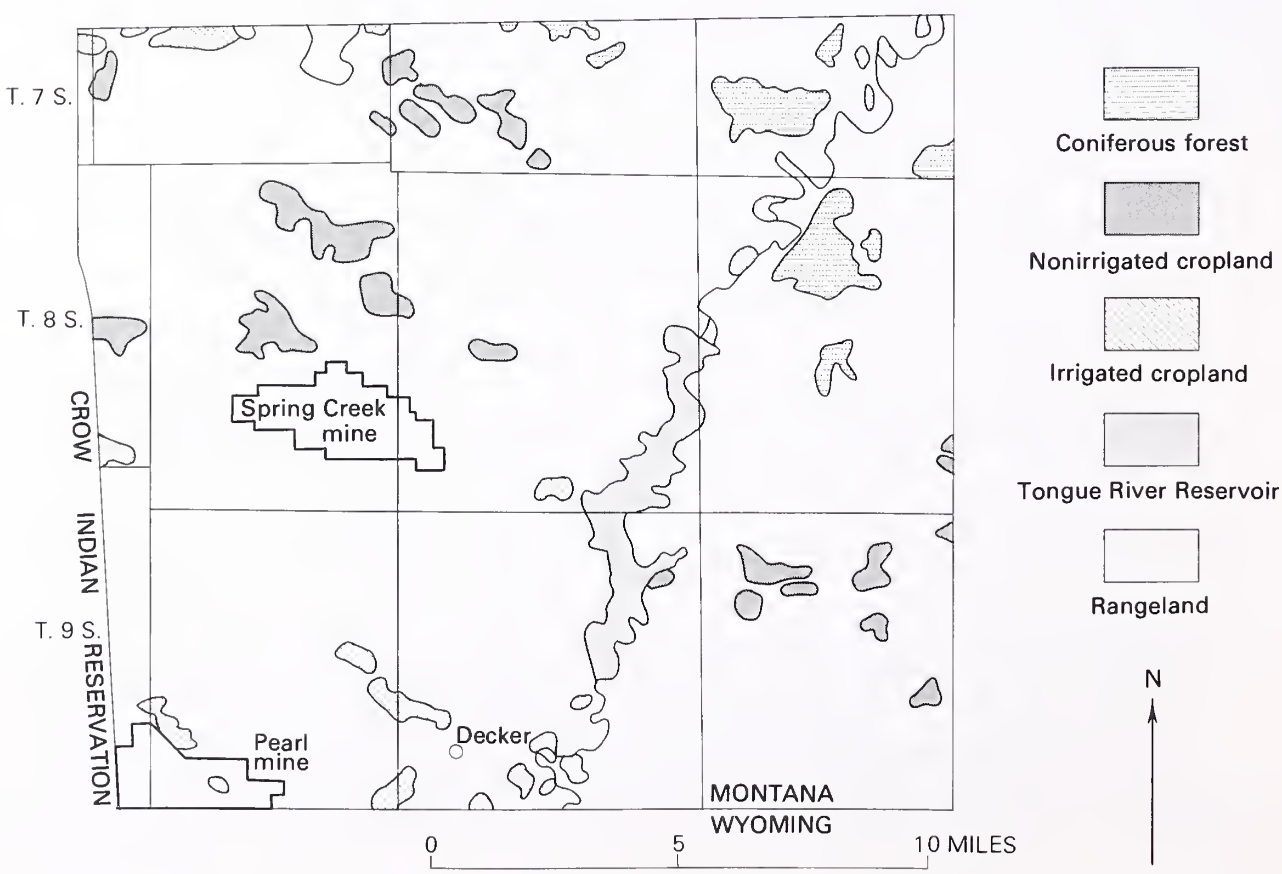


FIGURE II-41.--Land use in the Decker subregion. Map prepared by the Yellowstone-Tongue Areawide Planning Organization, 1977.

TABLE II-41.--Types of land use on farms in 1974 (acres)

[Source, U.S. Department of Commerce, Bureau of Census, Agricultural Census, 1974]

County	Total cropland	Irrigated cropland	Woodland including pasture	Other farm land[1]
Big Horn----	264,196	38,553	140,597	2,243,119
Rosebud-----	157,430	30,628	56,317	2,795,290
Sheridan, Wyo.------	114,946	56,385	6,306	1,350,020

[1] Includes mainly pasture and rangeland; also includes wasteland and a small amount of land in farmsteads, roads, and ponds.

More than 430,000 acres in the Ashland and Fort Howes Districts of the Custer National Forest, in Rosebud and Powder River Counties, is timbered, grazed, or used for recreation.

Permits for coal mines have been issued for more than 19,000 acres (nearly 30 mi^2) in the study area and for 14,336 acres (about 22 mi^2) in the designated region. Not all of this area would actually be mined. No permits have been issued for Custer or Treasure Counties, and a permit for 21 acres has been issued for Powder River County. Present land use for mining is clustered in two relatively small areas in the study area--in Rosebud County near Colstrip and in Big Horn and Sheridan Counties near Decker, where the mineable coal seams are thick, the retrievable tonnage per acre is high, and the ratio of Btu's/lb of coal produced is also high. The proposed mines are in these two areas. Westmoreland Resources, Inc., is currently mining Indian-owned coal near Sarpy Creek in the Crow Ceded Area.

Within the three-county study area, more than 55,000 acres are urban and built-up (about 86 mi^2, or 1.6 percent of the total study area) (table II-42).

The reservations are used mainly for grazing, subordinately for timbering and cropland--mainly dry farming (notably wheat) on the Crow Reservation and cattle feed on the Northern Cheyenne Reservation. Large areas of irrigated lands in and adjacent to the Crow coal resource area (U.S. Department of the Interior, 1970-78) in the eastern part of the Crow Reservation and on the ceded area are in the valleys of the Bighorn and Little Bighorn Rivers and tributary streams. These areas produce good yields of small grains, forage, and row crops.

Most land in the Crow Ceded Area is used for grazing and dry croplands. Croplands are irrigated along the streams, particularly in the lower Big Horn and Yellowstone Valleys.

TABLE II-42.--Urban and built-up uses, and coal mine lands

[Source: Northern Great Plains Resource Program, 1974]

Counties	Urban and built-up uses[1] Acres	Urban and built-up uses[1] Square miles	Permitted coal mine lands[2] Acres	Permitted coal mine lands[2] Square miles
Big Horn	11,979	18.7	9,610	15.02
Custer	14,307	22.4	---	---
Powder River	6,200	9.7	21	.03
Rosebud	5,208	8.1	6,862	10.72
Treasure	4,115	6.4	---	---
Sheridan, Wyo.	37,526	58.6	2,652	4.14
Total area				29.8

[1]Includes cities, towns, and other built-up areas of more than 10 acres, such as highways, roads, railroads, airports, golf courses, industrial sites, institutional and public administrative areas. Excludes strip mines and borrow pits.

[2]Acreage of mines under approved permits as reported by Montana Department of State Lands and Wyoming Department of Environmental Quality, April 1978.

L. TRANSPORTATION

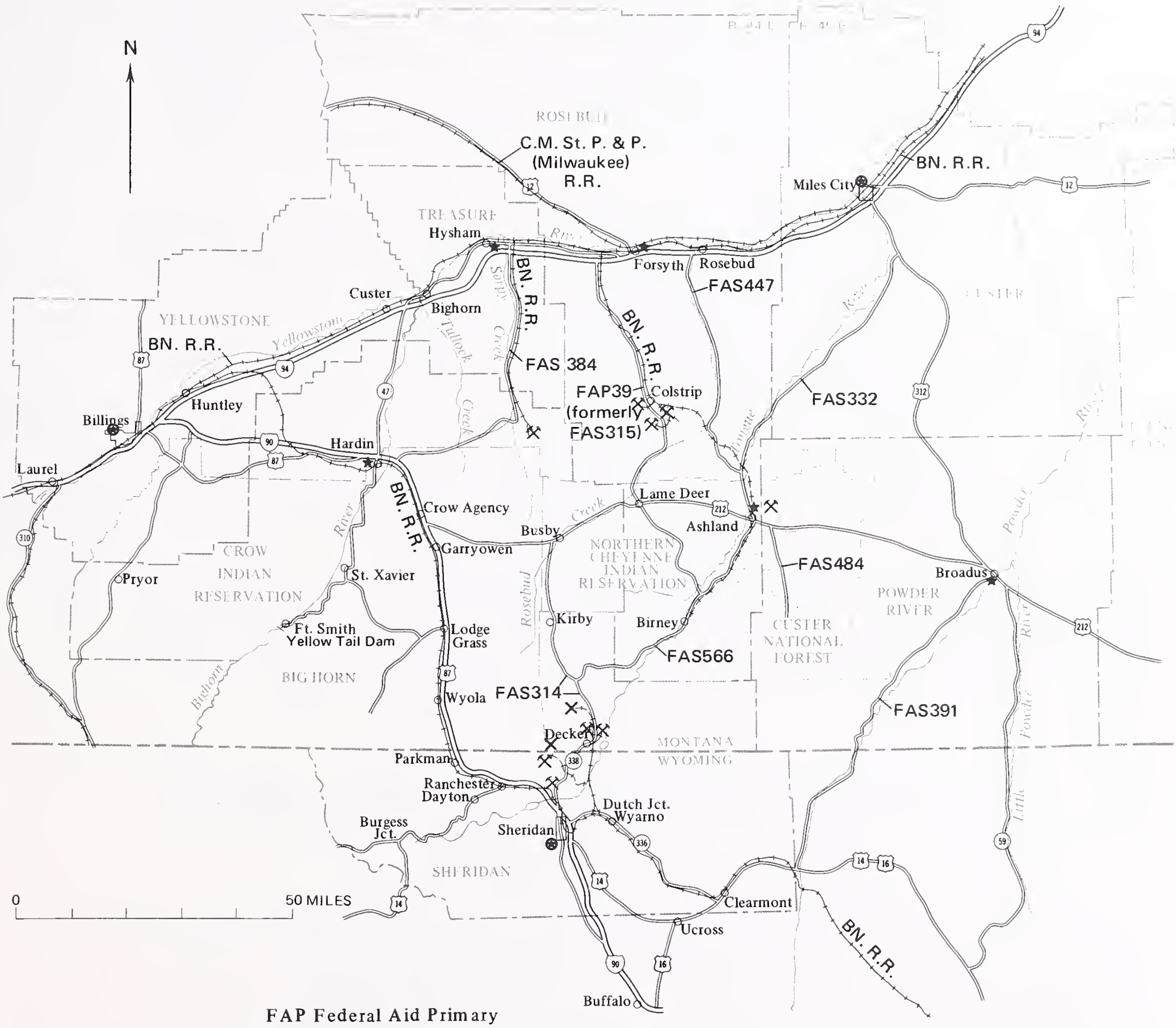
Due to sparse population and widely separated towns, most people and consumer goods in the study area move by roadways. The road network is not well developed but is generally adequate for existing population. (See figure II-42.)

Rail service, essential to the movement of coal, agricultural products and heavy freight, is provided by the Burlington Northern Railroad. Commerical passenger service is provided by bus on the Interstate highways, by AMTRAK along the Yellowstone Valley, and by air carriers at Billings, Miles City, and Sheridan.

Several oil and gas pipelines and major electrical transmission lines cross the area.

1. Highway System

Interstate 94 follows the Yellowstone Valley and Interstate 90 skirts the designated region on the west. About 55 miles of I-90 from Garryowen to the Tongue River in Sheridan County is still a 2-lane highway, which has noticeable traffic congestion during the summer tourist season. Funds for completion of the Montana portion of the Interstate are projected to be available between 1979 and 1982. Six other Federal highways cross the



FAP Federal Aid Primary Road system

FAS Federal Aid Secondary road system

Proposed railroad extension

★ Small craft airport

⊛ Commercial passenger service airport

⚒ Existing coal mine

✕ Proposed coal mine

—Regional transportation systems.

FIGURE II-42.--Transportation routes in the study area.

study area or adjacent Sheridan County. U.S. Route 212 is the major highway serving the southeastern corner of Montana. State and secondary routes in the area are also shown in figure II-42. The route from I-94 through Colstrip to Lame Deer was recently upgraded from Federal Aid Secondary (FAS-315) to Federal Aid Primary (FAP-39) status. This is a heavily travelled road, and the Montana Highway Department has begun reconstruction of 23 miles of road north of Colstrip.

A loose network of county roads provides ranchers and rural residents access to the primary and secondary road system. These are mostly gravel surfaced with curves and grades conforming closely to the existing terrain.

Figure II-43 shows the average daily traffic count (ADT) for rural road sections in the study area during 1977, and trends from 1975-77. Sheridan County ADT figures for 1977 are not yet available, so 1976 data are used. Nowhere does rural traffic approach the theoretical capacity for standard two-lane or multi-lane roads (1,000 vehicles/lane/hour), although effective capacities on individual road segments are less due to surface conditions, narrow shoulders, curves and grades, rail and road cross traffic, and the mixing of slow with faster moving vehicles.

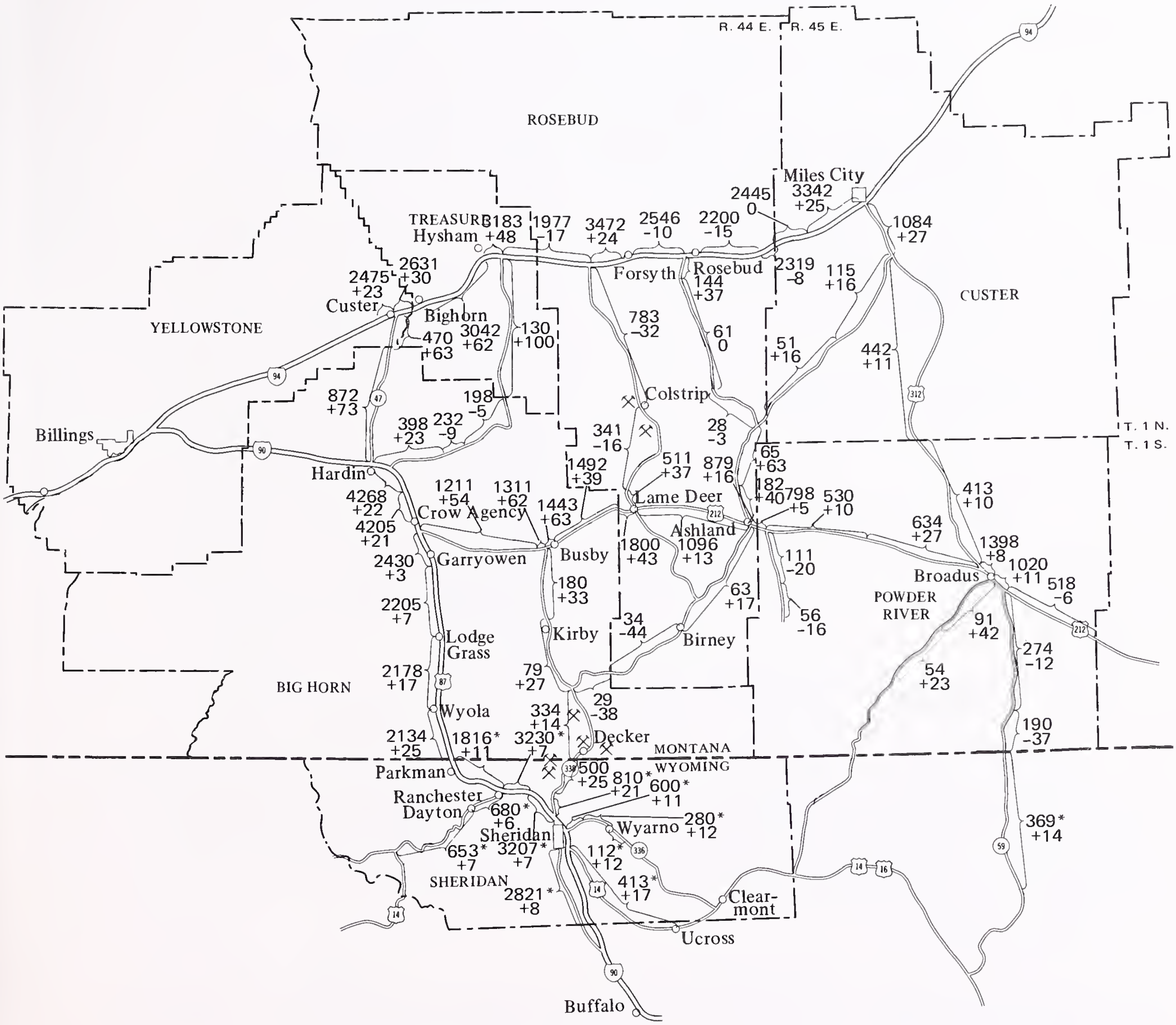
Traffic on most roads has increased, with a few segments rising between 50 and 100 percent. In this short time, local fluctuations are apparent, due mostly to opening of mines. The road segments north and south of Colstrip on FAP-39 (formerly FAS-315) show a decline of 32 and 16 percent respectively, due to the completion of Colstrip generating plants 1 and 2.

Traffic on segments of Wyoming State route 338 (Montana route 314) has grown 14-25 percent per year from 1975-77, due mostly to opening of mines near Decker. Short segments near Decker and the Montana State line show as much as four fold growth from 1975-77.

At-grade railroad crossings may greatly affect a road's capacity where rail traffic is heavy. These crossings also present some hazard to motorists and to the trains. Table II-43 lists crossings traversed by coal trains from the Decker, Colstrip, and Sarpy Creek areas.[10] This inventory includes a single crossing south of the Decker mine, crossings on the Sarpy Creek and Colstrip spurs, and mainline crossings from Sarpy Creek eastward to North Dakota. Eleven crossings are grade separated (overpass-underpass), eight are protected by crossing gates, 15 have flashing lights, 34 have crossbucks (rail crossing signs), and 4 have no protection. Crossings along the tracks from the Wyoming line to Huntley, Montana, and eastward to Sarpy Creek were apparently uncounted, although some Montana coal moves circuitously along this route.

---

[10] Montana Department of Highways, Planning & Research Bureau, Montana's Highway Needs Related to Hauling Energy Resources and other Energy Induced Needs, December 1976.



1492 Average number all vehicles per day, 1977

+39 Percent change in 1977 count over 1975 count

* Wyoming data are for year 1976 and percent change from 1975 to 1976

—Average daily traffic.

FIGURE II-43.--Traffic on rural road segments. Source Montana Department of Highways, 1977; Wyoming State Highway Department, 1977.

TABLE II-43.--Road-rail crossings traversed by Montana coal trains as of December 1976

[Source: Montana Highway Department, 1976]

Type of road	Number of crossings	Type of crossing protector
Interstate Federal aid system	2	Grade separation
Federal aid primary highways	4	Grade separation
Federal aid secondary highways	1	Grade separation
	2	Crossing gates
	7	Flashing lights
Federal aid urban routes	1	Grade separation
	1	Crossing gates
	3	Flashing lights
	1	Crossbuck
Off Federal system	3	Grade separation
	5	Crossing gates
	5	Flashing lights
	33	Crossbuck
	4	None
Total	72	

Table II-44 lists railroad crossing accidents occurring in and adjacent to the study area over a recent 5 1/2 year period. Twenty-one accidents were recorded (average 3.8/year). Four of these accidents resulted in a total of six fatalities. Six accidents resulted in personal injuries, and the remaining 11 resulted only in property damage.

2. Railroads

The rail network over the transportation study area is shown in figure II-42.

Burlington Northern ships coal from the region on three main lines. The main line between Billings and Glendive is used to ship coal from the West Decker mine to Superior, Minnesota, for transfer to water carrier, and for other shipments from the region and adjacent producing areas destined for points in Minnesota, Wisconsin, and the Chicago, Illinois area. A branch line extends from this main-line near Nichols 33 miles through Colstrip to Cow Creek. This lines serves Western Energy's mines as well as Peabody's Big Sky mine, which is connected by a 7.5 mile long rail spur. Another spur line extends from the mine-line near Hysham to the Absaloka mine near Kuehn.

The Burlington Northern Billings to Glendive main-line segment is joined by another main line at Huntley, approximately 12 miles east

TABLE II-44.--Train/vehicle accidents, January 1972-July 1977

[Source: Montana Department of Highways, Planning and Research Bureau, Project Planning Section]

Location	Type of crossing control	Date of accident	Type of accident
Colstrip			
Main Street-------	Crossing sign	10/10/73	Property damage
Rosebud			
Main Street-------	Flashing lights	2/10/72	Personal injury
Big Sky mine			
Rt. 315-----------	Flashing lights	10/24/73	One fatality
N. of Colstrip			
Sheep Creek/ Route 315---------	Crossing sign[1]	6/12/75	One fatality
N. of Colstrip			
Freeze Creek/ Route 315---------	Crossing sign[1]	12/17/75	Property damage
Forsyth			
Main St. crossing-	Flashing lights	4/14/77	Property damage
10th Ave. (center of town)	---	3/23/75	Personal injury
U.S. 12 at west end of town-----	Flashing lights[2]	3/06/73	Two fatalities
Decker/Route 314[3]---	Flashing lights	3/04/76	Property damage
Garryowen-----------	Crossing sign	12/10/76	Property damage
Crow Agency			
(private crossing)	---	12/13/76	Property damage
Hardin			
Center Street-----	Crossing sign	4/10/75	Property damage
Miles City			
County road W. of Tongue R.[4]------	---	3/14/73	Personal injury
Spotted Eagle Rd.-	---	1/22/72	Property damage
4th Street--------	Crossing sign	2/22/74	Property damage
Montana Avenue[4]---	Flashing lights	11/13/73	Personal injury
		8/17/76	Personal injury
N. 75h Street[4]----	Flashing lights	12/17/72	Property damage

[1]Crossing signs have since been replaced by flashing lights.
[2]This crossing is now grade separated with an overpass.
[3]This accident, although occurring on the crossing, apparently did not involve a train.
[4]Accidents occurring on the Milwaukee system--all others on the Burlington Northern.

of Billings. This line passes through Hardin, crosses the State line near Parkman and continues southeast through Wyoming. A spur line extends north from the main line just east of Sheridan, Wyo., for 25 miles, terminating in loading loops at the Decker mines.

The main line from Huntley to Sheridan continues southeast through Wyoming, providing the only rail service in the eastern Powder River coal region of Campbell and Converse Counties, Wyoming. An extension of the branch line to mines in these counties south to Orin, Wyoming, and an extension of a new branch line north of Gillette are presently under construction. East of Gillette, the main line continues southeast to Alliance, Nebraska, where rail traffic can continue east or interchange with other carriers in Omaha, Kansas City, southern Iowa, northern Missouri and western and northern Illinois. Traffic can also move south from Alliance entering Denver and connect to Burlington Northern's subsidiary, the Colorado and Southern. The line, together with another Burlington Northern subsidiary, the Fort Worth and Denver provides access to major Texas markets.

The third main line extends southeast from Laurel, Montana, through Wyoming, passing through Orin before reaching Wendover, Wyoming. From Wendover the line extends east to Northport, which is on the Burlington Northern main line between Alliance and Denver. The Colorado and Southern main-line also connects Wendover directly with Denver.

Freight movements dominate rail operations in the region. The only rail passenger service in the region is provided by AMTRAK over the Burlington Northern main line between Billings and Glendive; this run may be discontinued in the near future.

Traffic on the branch and spur lines in the study area consists almost exclusively of coal movement by unit trains, with remaining traffic being freight necessary to support mining operations. Unit trains, which are dedicated trains moving between a specific origin and specific destination, are the most common means of transporting western coal, with 110 cars the most common unit-train length on the Burlington Northern.[11] Based on estimates of coal production for 1978, an average of 16 unit trains per day (including returning empties) are generated by coal mining in the area. An average of 5 trains per day use the Colstrip-Big Sky branch. Three use the spur south of Sarpy Jct., and eight use the spurs from the Decker and Big Horn mines.

Burlington Northern is the dominant rail carrier serving the northern tier of States west of the Mississippi. Burlington Northern is the only railroad presently serving coal mines operating in the Fort Union formation. Recent trends toward greater use of low sulfur coal has resulted in a substantial increase in the volume of coal hauled by Burlington Northern. The railroad moved 23 million tons in 1972 and by 1977 was moving 42 million tons annually. Estimates for 1978 amount to 63 million tons; for 1979, 78 million tons.

---

[11] A number of calculations elsewhere in the text have been made on the basis of a more conservative average of 100 cars per unit train.

Table II-45 shows existing traffic levels (1977) on selected links of Burlington Northern's main lines. These links are shown in figure II-42.

TABLE II-45.--Existing traffic on selected links of the BN system

Segment	Link	Total trains	Number of coal trains
A----	Huntley to Sarpy Junction	9	3
B----	Sarpy Junction to Nichols	12	6
C----	Nichols to Forsyth	16	10
D----	Huntley to Billings	14.5	.25
E----	Billings to Laurel	14	0
F----	Huntley to Kleenburn	8	2
G----	Kleenburn to Sheridan	11	3
H----	Sheridan to Dutch	9	3
I----	Dutch to Campbell	10	4
J----	Campbell to Donkey Creek	11	5
K----	Donkey Creek to Alliance	22	14
L----	Alliance to Northport	9	---
M----	Laurel to Orin	4	---
N----	Orin to Wendover	4	---
O----	Wendover to Northport	4	---

3. Air Service

Billings, Sheridan, and Miles City have commercial passenger terminals plus mail, freight, and charter service. Billings' Logan Field is the busiest airport in the Great Plains region north of Denver, with connections to Seattle, Spokane, Denver, Salt Lake City, the Twin Cities, and numerous local points. There are five charter or air service companies at the Billings airport.

Sheridan, Wyoming, has scheduled commercial air service as an intermediate stop between Billings and Denver. Two commuter airlines began service to Sheridan in 1978 with connections to Gillette, Casper, Cheyenne, and Denver. Two charter services are also available. Commercial passenger boardings at the Sheridan Airport were 14,707 in 1976 and 15,863 in 1977 for a 1-year increase of 7.9 percent.[12]

4. Other Passenger Transportation

Passenger rail service is provided by AMTRAK, with stops in Miles City, Forsyth, and Billings. This service may be discontinued shortly as part of nationwide cutbacks in AMTRAK service.

---

[12] Assistant Manager, Sheridan County Airport, oral commun., August 28, 1978.

Trailways provides intercity bus service from Billings south via Interstate 94. The small communities adjacent to the study area between Hardin and Sheridan all receive service through scheduled or flag stops. From Sheridan, the route divides to Gillette and Rapid City, South Dakota, on the east and Casper, Cheyenne, and Denver to the south. Service on Greyhound Lines, Inc., connects communities along the Yellowstone with major cities east and west.

Miles City and Sheridan have taxi services as well as transportation services for senior citizens, handicapped people, special education needs, and hospital needs.

5. Crow Reservation Transportation

In addition to highway routes described above, two paved roads extend from southwest I-90 into the Pryor Mountains and to the Big Horn Reservoir. Along with I-90 in the Little Big Horn Valley, these routes provide transportation for the majority of the Crow population. See figure II-43 for average daily traffic counts on highways crossing the reservations.

6. Northern Cheyenne Reservation Transportation

The Northern Cheyenne Reservation lies near the center of the regional transportation system described previously. (See figures II-42 and II-43.) Transportation on or through the Reservation is entirely by road or highway. The main east-west route is U.S. 212 and north-south travel is provided by FAP-39 and FAS-314. FAS-314 is not paved on the Reservation. A good paved road connects Lame Deer with Birney Village on the Tongue River. This connects across the Tongue River with FAS-566 (unpaved) which parallels the eastern boundary of the Reservation. The remainder of the roads on the Reservation are of dirt or gravel construction, generally oriented along drainage courses.

M. RECREATION

Urban recreational facilities in Sheridan and Forsyth are underdeveloped, and in Sheridan they are poorly maintained (Meadowlark, 1978). They appear to be used at or above capacity. In Colstrip, the facilities are well developed and carefully maintained; use is rapidly approaching capacity. Because the region is rural, its recreation is mainly oriented toward outdoor activities, such as hunting, fishing, and snowmobiling. Outdoor facilities are generally not fully used, except at the Tongue River Reservoir. The region draws local and out-of-state hunters with excellent hunting success [Montana Statewide Comprehensive Outdoor Recreation Plan (SCORP), 1978]. Fishing is moderately good. Most streams are on private lands, but ingress is generally permitted with minimal restrictions; numerous ponds and lakes are scattered on both private and public lands. Overall, outdoor recreation use is not approaching capacity.

1. Outdoor Recreation

The Tongue River Reservoir provides opportunities, mainly to Decker and Sheridan residents, for camping, picnicking, boating, fishing, water skiing, and waterfowl hunting. Facilities include latrines and shelters at two semideveloped campsites, two natural boat ramps, and a vista area (See FES 79-10, Spring Creek mine.) These facilities are in generally poor condition, and, during the summer, demand exceeds capacity. Dispersed use of the reservoir occurs in scattered areas where unimproved roads provide access.

The Custer and the Big Horn National Forests are the major public lands in the study area. They provide a variety of outdoor recreation opportunities. The Ashland Division of the Custer National Forest is the only large block of publicly owned forested land in southeastern Montana. Some of the key recreational values include isolation from major population centers, diverse topography, and rugged, forested scenery. The major recreational opportunities include big-game hunting, upland bird hunting, riding, driving for pleasure, and picnicking. To date, hunting has been the preferred form of recreation. There are very few water-based recreational opportunities.

Recreation facilities in the Ashland Division consist of two campgrounds, two picnic sites, and two fishponds. Since there are no recreation attractions in or near the campgrounds, they serve primarily as a camping "motel" for summer vacationers. Most of the day-to-day use is by residents who live within 10 miles of the Division. The exceptions to this are along Highway 212 during hunting season, when out-of-state people and others visit the area. Historically, the Division has not been thought of as a place people "go to" for recreation, but, rather a place people "go by" on their way to the Beartooth Mountains, Yellowstone Park, or the Black Hills. Recreation use on the Division has not followed the national trend of constant increase: fewer people are using the area now than 10 years ago. There were an estimated 40,000 recreation visitor days (RVD's) use in 1965. This dropped to an estimated 38,000 RVD's in 1975 with a low of 14,600 RVD's in 1971.

The Tongue River Breaks, a roadless area of about 16,000 acres northeast of Birney on the Ashland Division, was recommended for wilderness classification by the President in 1979. This area and two other roadless areas identified in the Forest Service's RARE II process provide opportunities for nonmotorized recreation.

The Big Horn National Forest southwest of Sheridan offers hiking, camping, picnicking, sight-seeing, hunting, and fishing. Numerous lakes and streams provide an excellent basis for water-related activities. Developed recreation facilities consist of 2 downhill ski areas, 12 picnic sites, and 39 campgrounds. The Cloud Peak Primitive Area in the forest provides for such nonmotorized recreation as backpacking and cross-country skiing. In the Big Horn Forest, dispersed recreation has been steadily increasing. Motorized use made up 35 percent of this use in 1977. Use was 1.3 million RVD's for 1977 and is presently projected for 1.7 million RVD's by 1980.

Developed facilities within 50-miles of Forsyth include 28 camping units, 25 picnicking areas, 1 swimming area, 1 boat ramp, and 4 fishing access sites.

Other outdoor recreation resources include the Custer Battlefield National Monument and a number of historical sites. Regional recreation activities include river floating and moss agate collecting (local semi-precious stone).

2. Urban Recreation

In Sheridan, recreation facilities include a swimming pool, tennis courts, golf course, gymnasium, ice skating rinks, parks, playgrounds, ballfields, zoo, YMCA, civic center, and historic sites. Most of Sheridan's parks and ballfields are only partially developed, and many offer no facilities (Meadowlark, 1978). Only one playground is developed. The parks and fields are poorly maintained. The facilities are well used.

In and near Colstrip, outdoor recreation facilities include a 51-acre park system, a swimming pool, a wading pool, three tennis courts, three basketball courts, and five tot lots. Indoor facilities in a 16,000-square-foot community center include basketball, handball, and racquetball courts and an exercise room (Montana Power Company, 1977). Facilities are in good shape, but use is rapidly approaching capacity.

The Surge Pond Recreation Area near Colstrip totals about 6 acres and provides 12 picnic sites (in a grove of ponderosa pine), a sand beach, gravel paths, a scenic overlook on a bluff above the lake, open areas for field sports, and access for nonmotorized boating. The pond is stocked by the State Fish and Game Department.

In and near Forsyth, local and State parks provide boating, camping, fishing, picnicking, and playgrounds. The Rosebud County Fairgrounds is east of town. A nine-hole golf course west of town includes a clubhouse. Other facilities include an ice rink, baseball and football fields, indoor and outdoor basketball and volleyball courts, tennis courts, swimming and wading pools, and a bowling alley. One park has good facilities and is well maintained and well used. The other two parks, however, have poor facilities and are poorly maintained and poorly used. The tennis courts are well used, and the swimming pool is well used but needs maintenance to meet State health standards. Forsyth offers no recreation programs.

N. CULTURAL RESOURCES

The Powder River basin incorporates the largest and most significant block of Plains Indian cultural resources in the entire Western plains (Zeimens and Walker, 1977). These cultural resources are significant in part because they document population migrations during the ice ages. Cultural resources in the study area generally represent the prehistory of the surrounding Northern Great Plains and document some of the last great Indian conflicts.

1. Archeology

A few areas of Federal coal in the designated EIS region have been surveyed, mainly under mining company, BLM, and USGS contracts. Additional studies are being made in response to legal requirements (chapter III) for studying newly discovered sites. Most of the known sites appear to be types common to a larger region.

The scarce site types, such as animal kill and butchering sites, burials, rock shelters, pottery sites, and some lithic scatters are more easily judged highly significant because of their obvious potential to yield cultural information. Although the majority of lithic scatters and tipi rings are more common, they may contain information important to interpreting prehistory. However, proper evaluation of most of these sites can be made only after they are better understood through testing for the existence of subsurface cultural deposits.

Early prehistoric (10,000 B.C. to 6000 B.C.) artifacts found in the region include Agate Basin, Brown Valley, Clovis, Cody, Folsom, and Hell Gap projectile points; they are generally found with bones of extinct Pleistocene mammoths and bison. Clovis and Folsom points have been found on Youngs Creek northwest of the proposed Pearl mine. An Agate Basin point and a Hell Gap point were found at Pumpkin Creek (Davis, 1976), a Hell Gap point in the CX Ranch and Decker areas (Gregg, 1977), and a Cody point just north of the Decker mine (Fredlund, 1972).

Middle prehistoric (5000 B.C. to A.D. 200) sites are fairly abundant throughout the region. All surveys in the region have found projectile points common to this period; many of the points are the cornernotched variety (Davis, 1976; Beckes, 1974; Haberman, 1973; and McLean, 1975). Dart points from this period include Besant, McKean complex, Oxbow, and Pelican Lake.

Late prehistoric (A.D. 200 to A.D. 1700) sites are numerous throughout the region. A great variety of cultural material, including ceramics, has been found in these sites. The projectile points commonly are the small side-notched variety.

The Big Sky mine expansion area includes 10 sites. Additional surveys are currently being done.

The Pearl mine area includes 16 sites, one of which (Bunny Chase) has been determined eligible for nomination to the National Register of Historic Places. However, that site has been intensively studied and will probably be removed from the eligibility list. One remaining site will also be considered for eligibility. The remaining 14 sites are believed to be eligible for the National Register; however, the Montana State Historic Preservation Officer must concur with this determination as provided in 36 CFR 63.

The Spring Creek mine area includes 50 archeological sites, 16 of which have been determined eligible for the National Register. The

remaining sites are currently being evaluated in consultation with the State Historic Preservation Officer to determine their eligibility for inclusion on the National Register.

The proposed power-generating plantsites are on lands previously disturbed by mining and, thus, no longer contain cultural resources.

Homestead sites occur throughout the region. They were occupied from the late 1890's until the drought of 1921. Only a few would be affected by mining, and none has known historic significance. Other cultural resources related to the white settlement of the area include several battlefields, none of which would be directly affected by mining. (See Social Environment.)

O. ESTHETICS

Generally, the area that would be impacted by the proposed mines and generating units has few esthetically distinctive areas. Dominant use of the region is as rangeland, landscapes are largely undisturbed, and man-caused noises and odors are strongly localized. They are due mainly to vehicles, farm machinery, and livestock. Perhaps the only broad-scale disturbance is the slight reduction in visibility due to farming and electric-power generation. Most people would probably not drive to the coal-producing part of the region specifically for its natural scenic values but, rather, to the mountains surrounding the region. Nonetheless, many local residents consider the landscapes of the area to be rather attractive and about 5,500 people per year visit the mines themselves. (See Recreation.)

There are three classes of scenic quality for the region--"excellent" (class A), "good" (class B), and "average" (class C) (BLM Visual Resource Management System). Generally, the rolling plains around the ongoing and anticipated mines are classed as "good" to "average."

About half the region consists of "good" landscapes, which comprise low mountains, juniper-covered hills, isolated stands of mountain timber, scattered outcrops of clinker or sandstone, and dissected areas along ephemeral tributaries of major perennial streams.

The remaining half of the region consists mostly of "average" landscapes, which comprise open landscapes--plains or rolling hills covered by sagebrush or grass and interrupted by scattered buttes.

Only the Powder River Breaks consists of "excellent" landscapes--several square miles of steep canyon walls, buttes, and mesas southwest of Broadus; strongly colored soils and rocks constrast pleasantly with the vegetation there.

Present and projected mines are clustered mainly in "good" landscapes near Colstrip and in "average" landscapes near Decker. Most of

the present and projected mines would not be visible from highways; exceptions are the present Bighorn, Decker, East Decker, and Big Sky mine, which borders FAS-315. Most of the esthetic impacts have been and will be confined to within a few miles of the borders of the mines except for railroad and transmission-line corridors.

The present generating units are in "average" landscapes near Colstrip. Although they are visible to a great many people from State Highway 315, their impacts are otherwise confined to within a few miles of the units.

P. FUTURE ENVIRONMENT WITHOUT THE PROPOSALS

This section briefly describes the environment in 1990 that would be expected if the proposed mines and generating units were not approved. The discussion focuses on the impacts of those existing and projected coal-related developments (table I-1) to which the impacts of the proposals would be added.

Projected mining under "baseline" conditions (that is, the intermediate level in the absence of the proposed developments--see figure I-2) would disturb about 16,000 acres by 1990--about 13,000 acres by mining, and the remainder by ancillary facilities. (See figure IV-13.) These changes will be in the same general areas as the proposed developments.

Direct impacts on soils, vegetation, and topography would not significantly change land use patterns within or adjacent to the region. Localized impacts from projected mines cannot be predicted in the absence of detailed mine plans. Agricultural land use will continue to dominate. Farms and ranches will continue to be consolidated, and towns will continue to encroach very slightly on some of the more productive agricultural lands.

Water requirements in the Sheridan area will be about 1,400 acre-feet per year by 1990, about 50 percent more than in 1978. The increase is about 1.2 percent of Wyoming's share of the Tongue River. Water requirements for the towns of Hardin and Colstrip will more than double by 1990 (fig. IV-2); however, adequate water is available under their existing water rights. Ashland and Broadus are the only communities in the area that obtain their supply from wells; these towns will probably grow only slightly, and there will be sufficient ground water for their needs. Water used at the existing and projected mines, about 750 acre-feet per year, would not significantly deplete flows of the Tongue River nor would the quality of the Tongue River be degraded except, at times, locally.

Violations of air quality standards for TSP and dustfall are expected to become more frequent in the Colstrip nonattainment area and in the Decker area. Projected population increases will substantially increase pollutant emissions in Colstrip, Forsyth, Hardin, and Sheridan. Sheridan will continue to be the most polluted town in the study area, although pollution in Hardin and Colstrip will increase at a faster rate.

Under existing control efficiencies, Colstrip generating units 1 and 2 will not meet the revised EPA standard for SO_2 (0.61 lb/10^6 Btu) and the new source performance standard for NO_x (0.7 lb/10^6 Btu), largely because coal from area C will be burned after about 1982. Area C coal is lower in Btu content and higher in percent of sulfur (Montana Department of Natural Resources and Conservation, 1976) than coal from area E which is now being used. When burning area C coal, SO_2 emissions could be as high as 0.824 lb/10^6 Btu from unit 1 and 0.978 lb/Btu from unit 2. This will approach the existing State standard of 1.0 lb/10^6 Btu which applies to units 1 and 2.

Some mines will preclude use of portions of antelope and mule deer winter ranges in the Decker area. Other impacts on wildlife will be mostly limited to the vicinity of the minesites. Projected mining near Colstrip will disrupt some habitat used by ringnecked pheasant. No impacts on threatened or endangered species are anticipated.

The population of the six-county study area is expected to increase to 62,000 people in 1980 (24 percent above present) and 76,000 people by 1990 (52 percent above present). (See figure IV-11.) The distribution of the population will be similar to the present, although Colstrip will grow faster than the other towns.

Age distribution and sex ratio will continue to change as a result of mining. The young adult and middle age groups will continue to increase in proportion to the young and elderly groups. The number of elderly will increase more slowly than the rest of the population because towns, such as Sheridan, will become less attractive as retirement centers. The number of school-age children will increase, but recent high-school graduates will continue to leave the area. The ratio of males to females will continue to decrease, except near construction sites or boomtowns such as Colstrip, Forsyth, and Sheridan.

Coal mining and related development will help maintain the trend of increasing employment in the area. Total employment will increase perhaps by as much as one-third between 1975 and 1990. Agriculture will remain the region's dominant basic industry employer in 1990, despite a continuing decline in the number of farm workers. Most of the employment increase in the EIS region will be due to increasing employment in the basic sector, primarily mining and Federal Government. Sheridan is rapidly becoming a major trade center. Mining will probably replace agriculture as the dominant basic industry, but growth in the ancillary sector will likely eclipse both.

Median income (in constant dollars) will continue to decline as the proportion of lower paying jobs in the ancillary sector increases. In Rosebud, Big Horn, and Sheridan Counties, there were 1.1 ancillary jobs for each basic industry job in 1950; in 1975, this ratio had increased to 1.8; by 1990, the ratio is projected to be 2.3. In 1975, jobs in basic industries in Big Horn and Rosebud Counties paid, on the average, 1.5 times as much as jobs in the ancillary sector. (See table II-26.)

The Montana portion of the study area (Rosebud, Big Horn, Powder River, Treasure, and Custer Counties) shows a distribution between ancillary and basic employment comparable to the distribution found 10 years ago statewide. This 10-year lag has existed since at least 1940 and may increase to a 15-year lag as more workers in basic industries move into the area. The lag will then decrease as new jobs in the ancillary sector develop in response to new basic industry jobs. Sometime after 1990, both the study area and Montana will probably approach a maximum of ancillary employment.

Family income may not decline as much as individual income because some households would likely have two people with jobs in ancillary businesses. The projected decline in median income would not be due entirely to an increase in mining. The trend would probably continue even without mining, due in part to the region's reliance on agriculture. Projected coal mining could speed up the process.

In Big Horn County, yearly revenues in constant dollars will generally increase faster than yearly spending from 1978-90. Yearly expenditures will generally be greater than yearly revenues in Sheridan, Powder River, and Rosebud Counties. Revenues in Rosebud County will probably decrease from 1978 to 1982 because of depreciation of Colstrip units 1 and 2, local decreases in coal production lowering taxable value, and changes in the allocation of the coal severance tax. After 1980 a portion of the coal severance tax will no longer be rebated to Rosebud and Big Horn Counties. In 1977 this rebate supplied 29 percent of total tax receipts in Big Horn County and 10 percent in Rosebud County.

Yearly revenues will probably increase faster than yearly expenditures for Big Horn School Districts, and the opposite would occur for Sheridan, Powder River, and Rosebud School Districts.

Among the local governments in the region, municipalities will generally experience the greatest financing problems. Average per-capita town revenue will probably decline for each county. If municipal governments are to maintain the same level of services, taxes will rise and/or State and Federal subsidies will have to increase.

Some improvements in the regional highway system by 1990 are expected whether or not the proposals are developed. Interstate 90 will probably be completed between Crow Agency and Sheridan and about 120 miles of primary highway now classed as deficient will likely be reconstructed (Montana Department of Highways, 1977). Over the next decade, additional roads will deteriorate so that the net improvement will depend upon funding and the priority placed by the Montana Department of Highways on road improvement. The proposed railroad spur to the Shell Pearl property might still be built to the Youngs Creek area, where a future mine is under negotiation on the Crow Reservation.

Most projected impacts on recreation will be from population increases, not from direct impacts at the minesites. Developed recreation facilities in Sheridan and Forsyth will be stressed further; they are already above

capacity and are generally poorly maintained. The outdoor facilities at the Tongue River Reservoir will become still more overused. The increasing population will be fairly youthful and will noticeably increase outdoor use in the Big Horn Mountains. The increasing population will likely result in more closings of private land to public access, particularly on large coal company ownerships. Fishing and hunting pressure would thus become more concentrated on public lands.

CHAPTER III

PLANNING AND ENVIRONMENTAL CONTROLS

SMCRA - Surface Mining Control and Reclamation Act
NEPA - National Environmental Policy Act
FLPMA - Federal Land Policy and Management Act
CFR - Code of Federal Regulations
USC - United States Code
R.C.M. - Revised Codes of Montana
P.L. - Public Law
SIP - State implementation plan
MEPA - Montana Environmental Policy Act
MAC - Montana Administrative Code

This chapter summarizes Federal, State, and local governments' responsibilities to plan for and regulate surface coal mining and related resource uses. The laws, regulations, and policies governing coal-related development in the northern Powder River basin form the basis for the specific mitigating measures for the mining and reclamation plans. (See "Alternatives" chapters in the individual site-specific EIS's.)

The designated region includes Federal public lands and minerals managed primarily by the Forest Service, the Bureau of Land Management, the U.S. Geological Survey, and, to a lesser extent, the Bureau of Reclamation. The region also includes lands owned privately and by the State of Montana. Mineral rights for some privately-owned lands have been retained by the Federal and State governments under the terms of various homestead land grants.

The Federal Government regulates all coal leasing and mining on Federal lands and on private lands where subsurface minerals are federally owned. The State of Montana regulates coal mining on all lands within its boundaries (whether Federal, State, or private) and leases coal on State lands. Thus, the Federal mineral estate is regulated by both the Federal Government and the State of Montana.

The roles of the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS) in regulating surface coal mining have changed with the passage of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) and the creation of the Office of Surface Mining (OSM). The division of responsibilities between these agencies are summarized below.

OSM, in consultation with the surface-managing agency (BLM), the USGS, and the Montana Dept. of State Lands, recommends approval or denial of surface coal-mining permit applications to the Assistant Secretary for Energy and Minerals. OSM is the Federal regulatory authority responsible for, as lead agency, reviewing mine plans (permit applications); enforce-

ment of all environmental protection and reclamation standards included in an approved mining permit; the monitoring of both onsite and offsite effects of the mining operations; and abandonment of mines within the area of operation on a Federal lease.

The BLM formulates special requirements (to be included in mining permits on Federal coal) for the management and protection of all resources other than coal, and for the postmining land use of affected lands. The BLM, in consultation with USGS and OSM, is responsible for the authorization of rights-of-way for various ancillary facilities such as access roads, power lines, communications lines, and railroad spurs proposed on Federal lands outside the mining permit area.

Under the mineral leasing law, the USGS is responsible for reviewing mine plans for development, production, and coal-resource recovery requirements on Federal leases. The USGS is responsible for the maximum economic recovery of the Federal coal resource and for ensuring that the Federal Government receives fair market value for the coal resource.

A. FEDERAL LAWS AND REGULATIONS (GENERAL)

The Mineral Leasing Act of 1920 (41 Stat. 437, as amended; 30 USC 181 et seq.) and the Mineral Leasing Act for Acquired Lands (61 Stat. 913; 30 USC 351-359) provide the basic authorities for leasing Federal minerals.

The Federal Land Policy and Management Act of 1976 (90 Stat. 2743; 43 USC 1701-1771) authorizes the Bureau of Land Management to manage public lands for multiple uses such as mining, outdoor recreation, and production of natural resources.

Both BLM and USGS programs are carried out under the following regulations:

- 43 CFR 3041: Provides procedures to ensure that adequate measures are taken during surface mining of Federal coal to avoid, minimize, or correct damage to the environment and to avoid, minimize, or correct hazards to public health and safety.
- 43 CFR 3500: Provides procedures for leasing and management of Federal coal deposits.
- 43 CFR 2800: Establishes procedures for issuing rights-of-way to private individuals and/or companies on public lands.
- 30 CFR 211: Governs operations for discovery, testing, development, mining, and reparation of Federal coal under leases, licenses, and permits under 43 CFR 3500. The purposes of the 211 regulations are to promote efficient production practices without waste or unnecessary loss of coal; to promote operating practices that will avoid,

minimize, or correct damage to the environment, and avoid, minimize, or correct hazards to public health and safety; and to obtain a proper record of all coal produced.

The Surface Mining Control and Reclamation Act of 1977 (30 USC 1201 et seq.) regulates surface mining and the surface effects of underground mining of all coal deposits. This act is implemented by the Office of Surface Mining (OSM) under 30 CFR 700, which provide for:

- Environmental performance standards for surface coal mining and reclamation operations.
- Inspection and enforcement procedures, including assessment of civil penalties.
- Requirements and procedures for approval of State and Federal mining permits.
- Development of a permanent regulatory program to be incorporated into coal mining permits issued under State and Federal law.
- Requirements for surface coal-mining and reclamation operations on Federal public lands.
- Procedures for State and Federal designation of areas unsuitable for surface or underground coal mining.
- Special performance standards of reclamation to be met by all programs required by the law, and requirements for posting, release, and forfeiture of reclamation performance bonds.
- Requirements for development of Federal programs for those States that do not choose to develop a State program.
- Providing assistance to small operators in meeting permit application requirements.

Section 515 of SMCRA and Federal regulation 30 CFR 715.13 require that coal-mining operators, at a minimum, restore the affected lands to a usable condition equal to or better than their premining uses. The applicant must demonstrate in a mining and reclamation plan that post-mining reclamation can be accomplished; only then will a permit be issued.

BLM and the U.S. Forest Service also administer regulations under Executive Order 11514 (35 CFR 4247) and Executive Order 11991, for the protection and enhancement of environmental quality of lands affected by surface coal mining.

B. STATE AND COUNTY LAWS AND REGULATIONS (GENERAL)

All surface coal mining in Montana is regulated by State laws implemented by the Montana State Board of Land Commissioners and administered by the Montana Department of State Lands.

The Montana Strip and Underground Mine Reclamation Act of 1973, as amended, provides for protection of environmental, social, and cultural resources in and around coal mines within the State. The act requires prior approval of prospecting, mining, and reclamation plans by the Department of State Lands. The Department will deny approval of any plan whose implementation would permanently harm land that has irreplaceable ecological or cultural characteristics or that cannot be successfully reclaimed. Permits for mining are issued by the State for periods of 5 years. Noncompliance can result in suspension of the permit and/or fines assessed by the State. The Department requires the applicant to provide a demonstrably acceptable, comprehensive plan for surface reclamation and to post an adequate performance bond.

The Strip Mine Siting Act of 1974, as amended, regulates all on-site land disturbances associated with strip mining, such as installation of coal transport and handling facilities, powerlines, and buildings.

Under the Strip Mined Coal Conservation Act of 1973, coal must be mined so as to prevent waste and to allow the coal remaining in the ground to be mined later. The Department of State Lands administers both the Mine Siting and the Conservation Acts.

In 1977 the Federal Surface Mining Control and Reclamation Act superseded Montana surface mining laws in several areas. However, on July 17, 1978, the Board of State Land Commissioners issued regulations to make Montana State law as stringent as the Federal mining and reclamation requirements.

The State of Montana also enforces the following legislation:

- Strip-Mined Coal Conservation Act, 50-1601, R.C.M. 1947.
- Open Cut Mining Act, 50-1018, R.C.M. 1947.
- Montana Environmental Policy Act; Title 69, Chapter 64, Sections 1-18, R.C.M. 1947.
- Montana Utility Siting Act; Title 70, Chapter 8, Sections 1-23, R.C.M. 1947.

Roads or railroads must be abandoned in accordance with the provisions of MAC 26-2.10(10)S-10330 and MAC 26.210(10)S10340. Such roads or railroads must be reconditioned and seeded, and adequate measures taken to prevent erosion.

When mining and reclamation is completed, all roads must be closed and reclaimed unless the landowner requests in writing, and the Montana Department of State Lands concurs, that certain roads or specified portions are to be left open for future use.

SMCRA, FLPMA, and the proposed cooperative agreement between the Department of Interior and the State of Montana under Section 523(c) of SMCRA provide procedures for approving mining permits and licenses.

The Major Facility Siting Act of 1973 allows construction of certain large energy-conversion facilities only after the Montana Department of Natural Resources and Conservation (DNRC) has studied the proposed action and its board has issued a "certificate of environmental compatibility and public need." For example, coal-fired generating units, transmission lines, certain pipelines, and large-capacity utility projects are subject to this act. The DNRC study is generally issued as an EIS to partially fulfill the MEPA requirements for large projects.

The Montana Environmental Index (Environmental Quality Council, 1978), discusses the Montana laws and regulations controlling housing, solid waste, transportation, utilities, and pollution associated with mining.

C. FEDERAL AND STATE LAWS AND REGULATIONS, BY DISCIPLINE

1. Geology and Hydrology

a. Protection of mineral and paleontological resources

The Conservation Division of the U.S. Geological Survey establishes priorities for mining coal or drilling for oil and gas on public lands. Regulations 30 CFR 211.17 and 30 CFR 211.63 require Federal approval of any mining on public lands near wells or boreholes that could release oil, gas, water, or any other fluid. Paleontological resources are protected under the Montana State Antiquities Act (Part 4, Chapter 3, Title 22, MCA), the Federal Antiquities Act of 1906, and the Federal Land Policy and Management Act of 1976.

b. Flood-plains management

Executive Order 11988, May 24, 1977, directs Federal agencies to take appropriate actions to avoid, insofar as possible, long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid support of new flood-plain development wherever there is a reasonable alternative.

c. Water quality

Federal water-quality legislation and regulations include the Federal Water Pollution Control Act (FWPCA), as amended in 1972 (33 USC 466); the Water Quality Act of 1965 (33 USC 1151); and the Water Resources Planning Act (42 USC 1462).

The Federal Water Pollution Control Act, as amended in 1972, establishes national standards to restore and/or maintain the chemical, physical, and biological integrity of the nation's waters. The act is implemented by the Environmental Protection Agency. The standards specify maximum short-term and long-term concentrations of pollution; minimum permissible concentrations of dissolved oxygen and other matter; water temperatures; and maximum amounts of pollution and wastes which may be discharged into waters.

Montana laws which protect the State's water resources include the Water Pollution Control Act, Title 69, Chapter 48, Sections 4801-4827, R.C.M. 1947; the Water Use Act of 1973; Revised Water Pollution Control Act of 1971.

The Water Pollution Control Act of Montana, which meets the requirements of the Federal Water Pollution Control Act, as amended in 1972, includes standards to protect water quality and flow levels and requirements for pollutant discharge permits. The Water Quality Bureau of the Montana Department of Health and Environmental Sciences has the primary responsibility for the control of water pollution in the State.

The Water Use Act of 1973 establishes procedures for adjudication in surface- and ground-water-rights disputes. The Department of Natural Resources and Conservation administers this law and monitors ground-water supplies to ensure that aquifers are not depleted by excessive withdrawals. The Board of Natural Resources and Conservation may approve water reservations by Federal, State, and local agencies for beneficial uses, such as reservations of streamflow for protection of fish, wildlife, and recreation or for agricultural, municipal, or industrial use. Use of water for a coal-slurry pipeline is not considered to be a beneficial use under the 1973 act.

Shallow wells made unusable by drawdown from mine pits must be replaced (sec. 22(3), Title 50, Ch. 10, R.C.M. Montana 1947).

The 1950 Yellowstone River Compact also regulates water use in the study area. The compact allocates water between Montana, Wyoming, and North Dakota; large diversions within the Yellowstone River basin must have the consent of all three States. A moratorium preventing further diversion of water from the Yellowstone River basin was enacted by the Montana legislature in 1973 until the Board of Natural Resources and Conservation allocated water reservations within the basin.

Pollution by municipal, industrial, or agricultural discharges is forbidden. Further, radioactivity and salinity are to be maintained at the lowest possible levels. Also, the State of Montana Water Pollution Control Council administers Water Quality Standards and the Surface Water Use Classifications of Montana, October 5, 1967, as well as adhering to the 1962 U.S. Public Health Service Drinking Water Standards where applicable.

The Natural Streambed and Land Preservation Act of 1973 and the Stream Preservation Act of 1929, administered by the Montana Department of Fish and Game, set policies for protecting natural rivers and streams and provide procedures which allow State or local agencies to alter streambeds. In addition, alteration of stream channels may require consultation with the U.S. Fish and Wildlife Service under the Fish and Wildlife Coordination Act.

The Department of Army, Corps of Engineers is responsible for ensuring compliance with Section 404 of the Federal Water Pollution Control Act and Section 10 of the River and Harbor Act of 1899. These regulations are contained in 33 CFR 209.12 and require issuance of permits for a wide variety of actions relating to crossings of navigable streams and alteration of stream beds (see section 7, Land use.)

d. Alluvial valley floors

The Surface Mining Control and Reclamation Act of 1977 requires preservation of the hydrologic balance of alluvial valley floors in the Western United States. State and Federal regulatory agencies designate a valley as an alluvial valley floor using geomorphic, hydrologic, and land-use criteria. Under 30 CFR 715.17 (j), surface-mining operations in or adjacent to designated alluvial valley floors must be planned and conducted to "preserve the essential hydrologic functions of these alluvial valley floors throughout the mining and reclamation process."

e. Water impoundments

The Department of Natural Resources and Conservation issues permits--subject to operator compliance with the Reservoir Salvage Act of 1960 (74 Stat. 220) and the National Environmental Policy Act (NEPA) of 1969 (33 Stat. 852; 42 USC 4321 et seq.)--for water impoundments on public lands containing important cultural and recreational resources. A planned reservoir that occupies public land surface or mineral estate and whose water is designated for another federally approved project is subject to the requirements of NEPA, the salvage requirements of the Historical and Archeological Data Preservation Act of 1974, and the Fish and Wildlife Coordination Act of 1958. Culturally valuable items that are found must be evaluated under the provisions of Section 106 of the National Historic Preservation Act and Section 2(b) of Executive Order 11593 by the Federal agency involved.

To approve a water impoundment for a proposed mining and reclamation plan, SMCRA requires the applicant to demonstrate that precipitation,

runoff, and ground-water inflow to the impoundment be of suitable quality and quantity to sustain livestock.

2. Air Quality

Federal legislation and regulations relating to air quality include the Clean Air Act of 1970; National Ambient Air Quality Standards (NAAQS); New Source Performance Standards (NSPS); Clean Air Act, as amended in 1977 (42 USC 7401 et seq.); and the Prevention of Significant Air Quality Deterioration Regulations of 1978.

Montana is currently drafting regulations to meet its enforcement responsibilities under the Federal Clean Air Act. Montana air-quality guidelines under the Clean Air Act of Montana do not now have force of law; therefore, Federal standards are generally used for the analysis of impacts in this EIS.

The Clean Air Act Amendments establish primary and secondary national ambient air-quality standards (NAAQS) for six pollutants (table III-1). The primary standards were established to protect human health; the secondary standards, to protect the general public welfare.

TABLE III-1.--Federal ambient air quality standards

Pollutant	Averaging time	Federal primary standards[1]		Federal secondary standards[1]	
		$\mu g/m^3$	ppm	$\mu g/m^3$	ppm
Sulfur dioxide-----	Annual (arithmetic)-	80	0.03	---	---
	24-hour-------------	365	.14	---	---
	3-hour--------------	---	---	1,300	0.5
Total suspended particulates-----	Annual (geometric)--	75		60	
	24-hour-------------	250		150	
Carbon monoxide----	8-hour--------------	10,000	9	10,000	9
	1-hour--------------	40,000	35	40,000	35
Photochemical oxidants (ozone)-	1-hour--------------	160	.08	160	.08
Nonmethane hydrocarbons[2]----	3-hour (6-9 a.m.)---	160	.24	160	.24
Nitrogen dioxide---	Annual--------------	100	.05	100	.05

[1]National Ambient Air Quality Standards (40 CFR 50); standards for averaging times of less than 1 year are not to be exceeded more than once a year.

[2]Set as a guide to achieve to photochemical oxidant standards.

Regulations implementing the Clean Air Act, as amended, are primarily developed and enforced by the U.S. Environmental Protection Agency (EPA) through 40 CFR 50-54 and 40 CFR 60.

The 1977 Clean Air Act Amendments set forth requirements for the prevention of significant air quality deterioration (PSD) for total suspended particulates and sulfur dioxide (table III-2). These requirements have only recently been implemented by the EPA through revisions to 40 CFR 52. The regulations will be enforced by the EPA until the State of Montana includes them in its implementation plan.

Federal actions may require permits from EPA demonstrating compliance with the Prevention of Significant Deterioration (PSD) increments and the Northern Cheyenne Indian Reservation Class I PSD increments.

Under the 1977 Amendments, all areas of the country were designated as Class II except for "mandatory" areas designated as Class I. Class II areas can be reclassified by the State; Class I areas cannot be reclassified at all. The Northern Cheyenne Reservation was designated Class I in 1977 at the Tribe's request (1976).

Specific regulations required for PSD are set forth in 43 CFR 118, through which EPA excludes, from any air-quality impact assessment of a source, any fugitive dust (soil uncontaminated by industrial pollutants) that would result from the proposed activity. EPA further stipulates that each mine operator must use the best management practice for fugitive dust, regardless of predicted levels of concentration.

The Environmental Protection Agency stipulates some combination of the following best management practices to control fugitive dust:

- Pavement or equivalent stabilization of all haul roads in place for more than 1 year.

- Use of semipermanent dust suppressants on all haul roads in place for more than 2 months but less than 1 year.

- Watering of all other roads before and during use where unstabilized material is present.

- Use of negative-pressure bag house or equivalent methods (such as conveyor and transfer-point coverings, spraying, and coal loadout silos) at all coal dumps (truck to crusher).

Any mining operation that has the potential to emit 250 tons/year of total suspended particulates must apply for a PSD permit.

PSD regulations require two levels of analysis for most proposed mining operations to determine the TSP impact on air quality. First, best available control technology (BACT) measures must be determined for the proposed operations. Second, if nonfugitive dust emissions exceed 50

TABLE III-2.--Prevention of significant deterioration (PSD)

	Maximum allowable increase ($\mu g/m^3$)
Class I	
Particulate matter:	
Annual geometric mean---------	5
24-hour maximum---------------	10
Sulfur dioxide:	
Annual geometric mean---------	2
24-hour maximum---------------	5
3-hour maximum----------------	25
Class II	
Particulate matter:	
Annual geometric mean---------	19
24-hour maximum---------------	27
Sulfur dioxide:	
Annual geometric mean---------	20
24-hour maximum---------------	91
3-hour maximum----------------	512

tons/year, each proposed mine on a Federal lease must have a more detailed air-quality impact analysis, including increments, air-quality standards, soils, vegetation, visibility, and monitoring.

The Federal Clean Air Act of 1970, administered by EPA, stipulates that each State is responsible for achieving and maintaining air quality within its borders. The Clean Air Act of Montana is designed to meet the State responsibilities under the Federal Clean Air Act. The Montana Department of Health and Environmental Sciences is responsible for developing and implementing a State implementation plan (SIP) to meet these EPA requirements, as follows:

- Air-quality-maintenance areas (AQMA) for which comprehensive plans (SIP's) are implemented to control air pollution.

- PSD of air quality--that is, the addition of any new sources of air pollution in an area--must be offset by reductions in pollution from other sources in the same area.

- Use of BACT to control fugitive dust and dust emissions. Best available control technology (BACT) is determined by EPA for each mine, on a

case-by-case basis, taking into account not only technical feasibility, but also relative costs of implementation in terms of both dollars and energy. Analyses of air quality in this environmental statement assume that, in accordance with Sec. 515(6)(4)(17 and 24) of SMCRA, the best technology currently available (BTCA) provides a reasonable basis for comparison of fugitive dust emissions with PSD standards.

New Source Performance Standards to regulate emissions from such sources as coal-fired power-generating units (table III-4). The NSPS applies to one unit at a time and does not limit the total amount of emissions from several units in the same place. Since the air-quality standards on the Northern Cheyenne Indian Reservation are stringent, the U.S. EPA has asked that the SO_2 emission rate from units Colstrip 3 and 4 be lowered to 0.61 lb/10^6 Btu (table III-3).

TABLE III-3.--New Source Performance Standards (NSPS), Federal and Montana

	Allowable emissions[1] (lb/10^6 Btu)		
	NSPS	Montana	U.S. EPA
Particulates	0.10	0.14	---
Sulfur dioxide (SO_2)	1.20	1.00	0.61
Nitrogen oxides (NO_x)	0.70	---	---

[1]The lowest limitation applies.

Montana has adopted the ambient air-quality standards as set forth in the Federal Clean Air Act, as amended in 1977. The Big Sky mine, for example, is in a "nonattainment area," for which the Montana Air Quality Bureau must write a SIP that provides for the attainment of primary air quality standards and of secondary standards for TSP. The State, by means of the SIP, will not allow construction or modification of any major stationary sources in a nonattainment area if emissions from the source would cause concentrations of any pollutant to exceed its national ambient air quality standard [Sec. 110(a)(2)(1)], unless the particulate emissions are offset by an emissions decrease elsewhere. Major stationary sources for particulates are those having potential emissions in excess of 250 tons/year [Sec. 169(1)]. Emissions from both the Big Sky and the Rosebud mines have, in the past, exceeded this amount, and, therefore, are considered to be major stationary sources.

3. Soils and Vegetation

The Montana Strip and Underground Mine Reclamation Act, in defining successful reclamation, requires that the reclaimed land and vegetation "provide a suitable permanent diverse vegetative cover," capable of:

- Feeding and withstanding grazing pressure from a quantity and mixture of livestock and wildlife at least comparable to that which the land could have sustained before mining.

- Regenerating itself under the natural conditions prevailing at the site, including occasional drought, heavy snowfalls, and strong winds.

- Preventing soil erosion greater than that which occurred before mining.

Rules regulating surface and underground mining of coal adopted by the Board of Land Commissioners on July 17, 1978 further require that the baseline for measuring compliance on lands that received improper premining management will be unmined surrounding lands that have received proper management (26-2.10(10)-S10311, para. 2(b)). The rules also require a "vegetative cover of the same seasonal variety native to the area of disturbed land," (26-2.10(10)-S10350, para. (3)) and a diverse vegetative cover of "predominantly native species." (Ibid., para. (4)); except that reclamation to other than native species may be approved subject to rigorous requirements. Protection of endangered species of plants, as well as animals, is required under the Endangered Species Act.

Additional requirements may be imposed by the Department of State Lands if special drainage or steep terrain problems are likely to be encountered. Topsoil will be salvaged from all roadways.

State and Federal agencies require that materials harmful to re-vegetation, plant establishment, and growth not be left on the top or within 8 feet of the top of regraded spoils or on the surface of any other affected areas. State and Federal agencies have the authority to require that problem materials be placed at a greater depth. Table III-4 shows concentrations ("suspect levels") at which materials may require burial.

4. Wildlife

a. Endangered species

The Endangered Species Act of 1973 (87 Stat. 844; 16 USC 1531-1543) protects listed species (vegetation, mammals, birds, fish, etc.) and their critical habitats. Before any lands can be disturbed under lease or permit, the Department of the Interior will make a survey to determine whether any species listed as threatened or endangered, or their habitats, are present. If any species that may be affected is present, the U.S. Fish and Wildlife Service must render a biological opinion under Sec. 7 of the Endangered Species Act before a permit can be issued. No actions will be authorized until this mandatory consultation is completed.

The Migratory Bird Treat Act (40 Stat. 755, as amended, 44 Stat. 1555) and the Bald Eagle Protection Act of 1969 (16 USC 668) provide

TABLE III-4.--State suspect levels

[Parts per million unless otherwise indicated]

Parameter	Suspect level
pH	8.8-9.0
Conductivity (soluble salts)	4-6 mmhos/cm
Sodium-adsorption-ratio	12
Texture	40-percent clay
Boron	8
Cadmium	0.1-1
Copper	40
Iron	Not defined
Lead	(pH 6 (10-15); pH 6 (15-20);
Manganese	60
Mercury	0.4-0.5
Molybdenum	0.3
Nickel	1.0
Selenium	2.0
Zinc	40
Ammonium-nitrogen	Not defined
Nitrate-nitrogen	Federal drinking water standard is 10; Federal livestock standard is 45

that no mining operations are to be permitted in any area where the activities would harm or disturb migratory songbirds and raptorial birds, including bald or golden eagles, or their nests.

b. Fish and wildlife resources

Under the Fish and Wildlife Coordination Act of 1958 (16 USC 470), the U.S. Fish and Wildlife Service is to be consulted about any alteration of a stream or other body of water that would affect the habitat of any fish or associated wildlife resource.

Federal regulations implementing the Migratory Bird Treaty Act prohibit the taking of migratory birds, their eggs, or nests. Migratory birds (50 CFR 10.13) include most birds currently nesting in the region. The U.S. Fish and Wildlife Service may authorize removal of these nests subject to stipulations.

The Montana Fish and Game Commission, acting through its department, regulates the use and protection of fish and wildlife, including management of nongame wildlife, and protects endangered species.

5. Economics

Two important taxes imposed recently on mine properties are the severance tax on coal and the resource indemnity trust tax. The gross-proceeds property tax on mine production is also an important source of revenue for State and local governments. (See ch. II, Economics.)

6. Community Services

The Resource Conservation and Recovery Act of 1976 (solid waste disposal), P.L. 94-580 (90 Stat. 2795), provides a method for technical and financial assistance to planners in the recovery of energy and other resources from discarded materials and in the disposal and/or management of hazardous wastes.

7. Land Use

Pursuant to Section 522 of the Surface Mining Control and Reclamation Act and the selective denial provisions of the Montana Strip and Underground Mine Reclamation Act (section 82-4-227 MCA), all mining activities, including highwall reduction and related reclamation, must cease 100 feet from property lines, permanent structures, unminable, steep, or precipitous terrain, or any area determined by the Montana Department of State Lands, in concurrence with the Secretary of the Interior, to be of unique scenic, historical, cultural, or other special value.

Executive Order 11990 (May 24, 1977) directs Federal agencies to avoid, insofar as possible, long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid support of new construction in wetlands wherever there is a reasonable alternative. A Corps of Engineers permit is required, under paragraph 404 of the Federal Water Pollution Control Act Amendments of 1972, to place fill in a wetland or navigable stream. For streams having an average annual flow of less than 5 ft^3/s, a project must comply with the 1977 "Nationwide Permit" regulations (42 CFR 138).

8. Transportation

a. Highways

The Montana State Highway Department requires prior approval for the relocation or crossing of a State highway and has jurisdiction over the public roads and highways within the study region. Any relocation, addition, or alteration of the Federal-aid highway requires compliance with both the Federal and the State Environmental Policy Acts (NEPA and MEPA).

In Montana, the Public Service Commission and the State Highway Department have jurisdiction over railroad construction and abandonment and any necessary crossing of public roads by a railroad.

b. Railroads

The Interstate Commerce Act (49 Stat. 543; 49 USC 1(18)) requires approval from the Interstate Commerce Commission for extension or new construction of a line of railroad or for abandonment of a rail line. Spur lines, industrial track, switching, or side tracks wholly within one State are exempted from this requirement.

9. Cultural Resources

Federal legislation and regulations that apply to cultural resources include:

- Antiquities Act of 1906 (34 Stat. 225; 16 USC 431-433)
- Historic Sites Act of 1935 (49 Stat. 666)
- National Historic Preservation Act of 1966 (80 Stat. 915; 16 USC 470)
- National Environmental Policy Act of 1969 (33 Stat. 852; 42 USC 4321 et seq.)
- Historical and Archeological Data Preservation Act of 1974 (88 Stat. 174; 16 USC 469)
- Executive Order 11593, "Protection and Enhancement of the Cultural Environment," 1971
- Procedures for the Protection of Historic and Cultural Properties (36 CFR 800)
- Federal Land Policy and Management Act of 1976 (90 Stat. 2743).

Cultural resources are protected by the above-named legislative acts, which regulate antiquities excavation and collection, protect cultural values on public lands, and provide for fines and/or imprisonment for violators. Procedures outlined in 36 CFR 800 require that certain Federal actions be submitted for review to the Advisory Council on Historic Preservation prior to approval.

Executive Order 11593 requires all Federal agencies to cooperate with non-Federal groups and individuals to ensure that Federal plans and programs contribute to the preservation and enhancement of nonfederally owned historic and cultural values. Section 2a requires that Federal agencies locate and inventory cultural resources and nominate eligible sites to the National Register of Historic Places.

BLM must coordinate professional surveys of cultural resources (archeological, architectural, and historical remains) with the Montana State Historic Preservation Officer (SHPO), the Advisory Council on Historic Preservation, and the Heritage Conservation and Recreation Service, after having received their written reviews and comments, before mining plans and/or rights-of-way applications can be approved. The USGS Area Mining Supervisor requires the company to notify him, prior to disturbance, of all archeological sites discovered during mining and to notify the appropriate officer of the surface management agency (BLM, USFS, and SHPO), prior to disturbance, of sites discovered during right-of-way construction.

The BLM and the USGS, in a memorandum of understanding, July 7, 1977, developed the "Cooperative Procedures Pertaining to the Protection of Cultural Resources Related to Onshore Mineral Leasing Operations, Exclusive of Oil, Gas, Geothermal Exploration, and Oil Shale." These procedures have been implemented for all proposed actions in the Northern Powder River Basin of Montana. BLM and USGS are continuing to develop technical guidelines for defining the resource and providing criteria for evaluation and measures for protection. Such provisions will serve as a basis for the protection program.

Through the Montana State Antiquities Act of 1973, the Montana Historical Society protects the archeologic, historic, scientific, and cultural sites on State lands. Stipulations typically added to a coal mining permit to comply with the law would be, at a minimum, as follows:

- Identification of prehistoric and historic features and listing of any features eligible for the National Register of Historic Places or the Montana Historic Sites Registry.

- Consultation with the State Historic Preservation Officer regarding any needed scientific excavation or further recording of significant remains not eligible for the National Register.

- Mandatory halting of mining if cultural remains are found during mining or construction, until remains are evaluated and reasonable time has been allowed to salvage those remains.

D. LAND USE PLANS AND CONTROLS

1. Federal Lands

a. BLM planning systems

All three proposed minesites include Federal lands managed by the BLM. The Federal Land Policy and Management Act of 1976 requires comprehensive land use planning on these lands. The Federal Coal Lease Amendments Act of 1975 directs that coal leases not be issued unless leasing and mining be compatible with the land use plans for the affected public lands.

BLM's planning process uses management framework plans (MFP's) based on resource inventories to establish coordinated land use allocations for all resources, and to establish objectives for each resource and support activity. From these broad guidelines in the MFP's, more detailed plans of action for resource management can be developed.

The FLPMA directs the BLM to inventory public lands and identify those lands having wilderness characteristics, as defined in the Wilderness Act of 1964. No tentative wilderness study areas have been identified on or near the proposed minesites.

b. U.S. Forest Service planning

Basic management direction of the National Forest System lands by the U.S. Forest Service, Department of Agriculture, is established principally under the Multiple Use Act of 1960, the Wilderness Act of 1964, NEPA, and the National Forest Management Act of 1976. Additionally, local management is developed through land use planning.

The designated region includes the Ashland Division of the Custer National Forest--an area specifically excluded from surface coal mining under SMCRA. A land use plan was prepared on both the surface and mineral resources for this division and was released as a draft environmental statement in October 1978. The Ashland Division land use plan does not recommend leasing federally owned minerals, but it considers acquisition or exchange of private subsurface mineral rights on National Forest land.

Based on the Forest Service's review, the President has recommended that one of three roadless areas identified on the Ashland Division be classified as a Wilderness Area under the Wilderness Act of 1964.

2. State and Local Land Use Plans and Controls

The State of Montana, through its Division of Planning, assists counties and municipalities in coordinating plans made at these levels with those of the Federal Government. Various State departments, such as Health and Education, have provided planning assistance in related programs for many decades.

City and county governments are authorized by the State to plan and zone within their jurisdictions. State law specifies the priority of county zoning over municipal authority. Counties are, however, specifically prohibited from regulating agriculture, forestry, and mining. By agreement between the State and local governments, all proposed mining developments covered by State laws are considered to be part of the mine and, therefore, are beyond the scope of local regulation. Any developments, such as manufacturing, not part of the mine may be regulated locally.

Local government approval is required for all subdivisions (parcels of 20 acres or less). The State Department of Community Affairs has set minimum subdivision standards which each city and county must enforce, and the Department of Health and Environmental Sciences requires all subdivisions to meet sanitary restrictions.

CHAPTER IV

IMPACTS

This chapter discusses the probable cumulative impacts that would result from implementation of mining and reclamation plans for three coal mines (Big Sky, Spring Creek, and Pearl) and two new generating units at Colstrip. These developments are proposed for Federal and State approval, and are considered as superposed on other developments expected in and adjacent to the designated region through 1990.

The evaluation of impacts is based on development as proposed and as governed by existing legal requirements. The mining and reclamation plans (hereinafter termed mine plans) in this statement were submitted for review prior to the passage of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) and regulations pursuant to that act. Therefore, in some cases the mine plans may not fully reflect the requirements of the law and the permanent regulations. However, the plans present sufficient data to permit analysis. Impacts of the mines are evaluated in more detail in their respective site-specific EIS's. (See FES 79-10, Spring Creek mine; DES 78-51, Big Sky mine, and vol. II of this statement, Pearl mine.)

Throughout this chapter, the significance of impacts is evaluated as measured by the degree to which the impacts would ultimately benefit or interfere with the anticipated uses of each resource. For example, adverse impacts of "relatively great" significance to water resources would cause relatively severe conflicts with anticipated water use. Most disciplines are introduced by a summary that assesses significance in this way. That summary is followed by documentation and explanation of its conclusions. The summary and documentation are separated by a double underscore.

In this chapter, as throughout the EIS, the "study area" refers to the area that would be impacted by the three proposed mines and two generating units. The sum of coal production from the three proposed mines plus the anticipated production from existing and projected (but not yet formally proposed) developments constitutes the "intermediate level of production." Existing and projected mines and generating units form the "baseline level" and are more fully discussed in chapter II. The intermediate level appears to be the most probable projection of current trends, and is the basis of analysis in this chapter.

This chapter also evaluates the impact of a new town of about 3,000 people in southern Big Horn County. This town would be associated with the proposed mines in that county, but is not subject to the same Federal and State approval as the mines.

A. GEOLOGY

1. Topography and Geomorphology

Geomorphic impacts on land use under the intermediate level of coal production would not be significant from a regional perspective. Locally,

however, impacts would be negligible to severe, depending on the success of reclamation at the minesites. Localized geomorphic impacts are summarized for the three proposed mines for which detailed mine plans are available. The probability of reclamation success at the projected minesites cannot be predicted in the absence of detailed mine plans.

The three proposed mines would disturb about 2,000 acres by 1990. Associated surface facilities would disturb about 1,000 additional acres. The impact of the proposed mines on post-mining erosion and sedimentation depends primarily on the specifics of the reclamation plans, which vary in their reconstruction of a geomorphically stable land surface. Impacts from the proposed mines are probably representative of impacts that could be anticipated from other projected mines in the region.

---

a. Impacts following mining

The postmining topography of the proposed Big Sky mine expansion would have relatively significant impacts, in that it would hamper anticipated postmining land uses for many decades. The originally proposed reclamation surface included numerous undrained depressions up to 10 acres in size. The depressions would accumulate saline soils, which would impede revegetation (Soils, chapter IV), and endanger cattle and wildlife (Land Use, chapter IV), until an integrated drainage network developed naturally across the reclaimed area and drained them. Increased sheet erosion along reclaimed highwalls would hamper revegetation. These impacts could be largely reduced through redesign of the mine plan. (See chapter VIII, DES 78-51, Big Sky mine.) A revised plan has been submitted and will be evaluated in the final EIS on the mine expansion.

Spring Creek Coal Company has proposed a 7 mty mine plan which would mine only the central portion of the coal field at Spring Creek. This plan is evaluated in FES 79-10. The State of Montana and the U.S. Department of the Interior have both approved the mine plan subject to stipulations.

Erosion on the reclaimed Spring Creek and Pearl minesites would not seriously curtail the use of land for grazing. The Spring Creek site might develop local erosion and sediment problems resulting from drainage channel extension on the reclaimed surface and from subsidence. The company has proposed to mitigate these problems as they arise. This may, however, require a longer term commitment to management than anticipated. (See Spring Creek FES 79-10.) The Pearl minesite might be subject to local erosion problems resulting from piping or from overly straight, uniform reclaimed hillslopes. (See Vol. II.) Even with successful reclamation, both minesites would be more susceptible to drought and erosion than undisturbed land surfaces.

Geomorphic impacts on the Spring Creek minesite would be more significant under an expanded 10 mty mine plan (DES 78-30, Spring Creek Mine), which the company may again propose in the future. Rilling and gullying

would be severe on the long regraded highwall slopes, and revegetation around the margins of the central plain would be impeded by heavy deposition of sediments from these rills and gullies. Once initiated, gullying would spread upstream into adjacent undisturbed land over a period of many decades.

Colstrip units 3 and 4 would be located on a relatively small, flat area without direct drainage to any streams, and thus would not have any significant geomorphic impacts--mainly a temporary increase in onsite erosion for a few years during construction. During operation of the generating units, erosion might well increase slightly in a few square miles east of the units if locally-degraded air quality reduced the density of vegetation that currently stabilizes the soils there. (See Vegetation, chapter IV.)

All three mines would release sediment-deficient waters from the settling ponds during mining, increasing the potential for channel incision as the stream regains its sediment load. This would probably not cause problems at the Spring Creek mine, where coarse alluvium would resist incision, or at the Big Sky mine, where released flows would probably not be so great as to cause incision. There is a slightly greater chance of incision occurring downstream from the Pearl mine, because water pumped from the mine pit would be added to perennial streamflow. This could locally lower alluvial water tables and reduce soil moisture, harming riparian vegetation (National Academy of Sciences, 1974).

Should mining or reclamation at the North Decker minesite initiate gullying in the Spring Creek drainage, it could spread upstream, and disrupt even a successful reclamation program at the Spring Creek minesite. The possibility of this occurring cannot be evaluated in the absence of a final mine plan for North Decker. The potential would be greater in South Fork Spring Creek because the alluvium there is relatively fine grained and, thus, relatively susceptible to erosion.

Sediment from the Pearl reclamation site would shortly reach the Tongue River. However, because the Pearl minesite would not be subject to large areas of severe erosion, little increased sediment would be added to the Tongue River. At Spring Creek and Big Sky, more sediment would be added to receiving streams. However, these streams are ephemeral, and the sediment would be temporarily stored along the alluvial channelways. Only after long periods of time (decades) or during severe storms would this sediment reach perennial streams where water quality could be degraded. Sediment eroded from the minesites during severe storms would be added to the heavy sediment load normally carried by the stormflows, and would constitute a relatively insignificant portion of the total sediment load. Deposition of excessive amounts of sediment could oversteepen downstream reaches of streams, possibly initiating gullying.

Existing and projected mines will disturb about 23,000 acres of land by 1990. These lands will be reclaimed, and the effects of mining and

the success of reclamation will depend on specific aspects of the reclamation plans. The probability of severe erosion and sediment problems cannot be generalized over the region. Depending upon the geomorphic stability of the reclamation surface, the geomorphic impact of mining could vary from a slight increase in the natural erosion rates to severe erosion both on the reclamation site and upstream through the affected drainage basin. If gullying occurs, land use could be limited in the areas affected.

Some geomorphic impacts would occur after reclamation under any surface mine plan in the region--they are common to strip mining in the semi-arid West. Even with successful revegetation, reclamation surfaces would generally have higher erosion rates than the premining surface because of the increased surface runoff resulting from decreased infiltration rates, and because the breakdown of soil structure would make the reclaimed surface more susceptible to erosion. In a study at the Big Horn minesite, Lusby and Toy (1976) observed an approximately threefold increase in runoff, and an approximately 8-fold increase above average natural rates in sediment yield on the reclaimed test site. With management, this increase in erosion would not be so severe as to limit land use, and it would not be permanent. However, it could last for many decades.

As vegetation becomes reestablished following reclamation, the premining infiltration rates would be partially restored, but the redevelopment of soil structure under the present climatic conditions would take hundreds of years. (See Soils, chapter II.)

Near Decker (fig. II-2), many of the existing and projected mines are along small tributaries to the Tongue River. Even if all those mines are successfully reclaimed, they will yield slightly more sediment to the Tongue River than the same areas did before mining. The amount of this increase is unknown, but it will probably not be great enough to affect channel equilibrium, to greatly increase the rate of filling of Tongue River Reservoir, or to greatly degrade water quality. On the other hand, if the minesites are not successfully reclaimed, they will probably erode severely, possibly degrading water quality.

Several existing and projected minesites are clustered along Armells Creek at Colstrip (fig. II-3), and successful reclamation at these sites may be interdependent. If gullying occurs in Armells Creek, either naturally or caused by the deposition of excessive sediment from severe erosion problems on one of the mined areas, it would spread upstream, possibly initiating erosion problems on other reclaimed minesites.

b. Impacts during mining

Stream diversions during mining would not erode if properly designed, but would lower the base level of adjacent hillslopes, causing higher erosion as the slopes adjust to the new equilibrium. Drainage ditches and diversions would also undercut adjacent hillslopes, and during periods

of intense rainfall, the hillslopes would be susceptible to local landslides. Sediment from ditches, diversions, and hillslopes would be trapped in settling ponds. A mine plan with adequately designed stream diversions, drainage ditches, and sediment retention facilities would cause minimal erosion and sedimentation off the minesite. Excess sediment would be trapped in settling ponds and any areas of erosion and sedimentation would be reclaimed.

2. Paleontology

Anticipated impacts on fossils would be of negligible significance: no fossils of exceptional scientific interest are believed to exist in rocks of the Fort Union Formation that comprise the overburden that would be disturbed at any of the proposed mines. (See Geology, chapter II.) Fossils of dinosaurs have been found in older rocks of Cretaceous age which are not part of the Fort Union Formation.

3. Geologic Hazards

The region has negligible geologic hazards, and none of the proposed developments would contribute to them.

4. Mineral Resources

During their anticipated lives, the three proposed mines would extract about 250 million tons of coal. That amounts to about 27 percent of the 924 million tons of coal expected to be mined concurrently in southeast Montana and north-central Wyoming by 1990, and about 0.6 percent of the estimated strippable reserves in the northern Powder River coal basin. Perhaps as many as 20 million tons of coal would be lost in mining--from thin, unmarketable rider seams above the main beds and from unavoidable losses incurred in mining. Mining would recover about 50,000 tons per acre at Big Sky, 144,000 tons per acre at Pearl, and 142,000 tons per acre at Spring Creek, based on an assumed 1,750 tons/acre-foot.

Coal mining would only negligibly hamper development of other mineral resources: none of significance are known at any of the proposed minesites. Moreover, known resources either occur in rocks beneath those that would be disturbed by mining (e.g., bentonite or oil and gas) or occur so commonly in the region that mining would not appreciably curtail them (e.g., clinker or sand and gravel).

B. HYDROLOGY

The intermediate level of coal production would probably cause very little conflict with other concurrent uses of water in the six-county study area (fig. IV-1). Existing, proposed, and projected mines would use little water relative to what would be available for other anticipated uses, and they would probably not cause enough degradation of water to interfere with other uses. Total demand in the study area would probably nowhere exceed available supply. Impacts on availability and quality of water

would probably be temporary and local. Water levels in perhaps six or eight wells within a mile or two of the proposed mines would be lowered as much as a few feet, especially during mining; similarly, a few springs would be destroyed or degraded by the mines. But the mining companies would be legally required to replace degraded supplies.

Neither the mines nor the populations they introduced to the study area would contribute appreciably to degradation of water quality except possibly for increases of unknown magnitude (a best guess is that they would be slight) in dissolved solids in wells within a few miles of the mines and for slightly and locally increased sedimentation during construction of mine facilities and mine-induced housing and railroads.

The proposed developments and the expanded population due to them would require about 22,600 acre-feet of water per year by 1990. The total water requirements for all coal-related development in the study area at that time would be 40,600 acre-feet annually (fig. IV-1).

Of the proposed developments, Colstrip units 3 and 4 would consume the most water--an average of 22,100 acre-feet per year. This water would be diverted by pipeline directly from the Yellowstone River. Water released from Bighorn Lake would offset the pumpage from the Yellowstone River, thus preventing depletion of downstream flow. Municipal requirements for Colstrip and Forsyth would add negligibly to the requirements for the generating units. The proposed mines would require about 160 acre-feet of water per year by 1990, increasing total usage from 750 to 910 acre feet per year (fig. IV-1). The requirement would be met mainly from groundwater inflow to the mine pits--with negligible impact on the Tongue River or its tributaries.

The increased population due to the proposed developments would require about 370 acre-feet per year by 1990 (figs. IV-1, IV-2). About half of that water would come directly from the Yellowstone River and about half from the Tongue River. Colstrip and Forsyth have sufficient water rights and supplies to provide the projected needs to 1990. However, Sheridan might have to acquire increased raw water storage for the projected population increase by the late 1980's. Unappropriated flow in the Tongue River Basin could be used, but additional storage would be required to prevent impacts on downstream water users. Total water use in the Sheridan area by 1990 would be about 1,500 acre feet per year, about 50 percent more than in 1978. The proposed mines would account for about 100 acre-feet per year of this amount.

The new town would require about 720 acre-feet annually. Although a source of water for the new town has not been specified, it is possible that a supply could be obtained from wells tapping clinker beds that probably crop out beneath the Tongue River Reservoir. In this case, pumping from the clinker would divert water from the reservoir, so the new town might require a contract for storage in the reservoir.

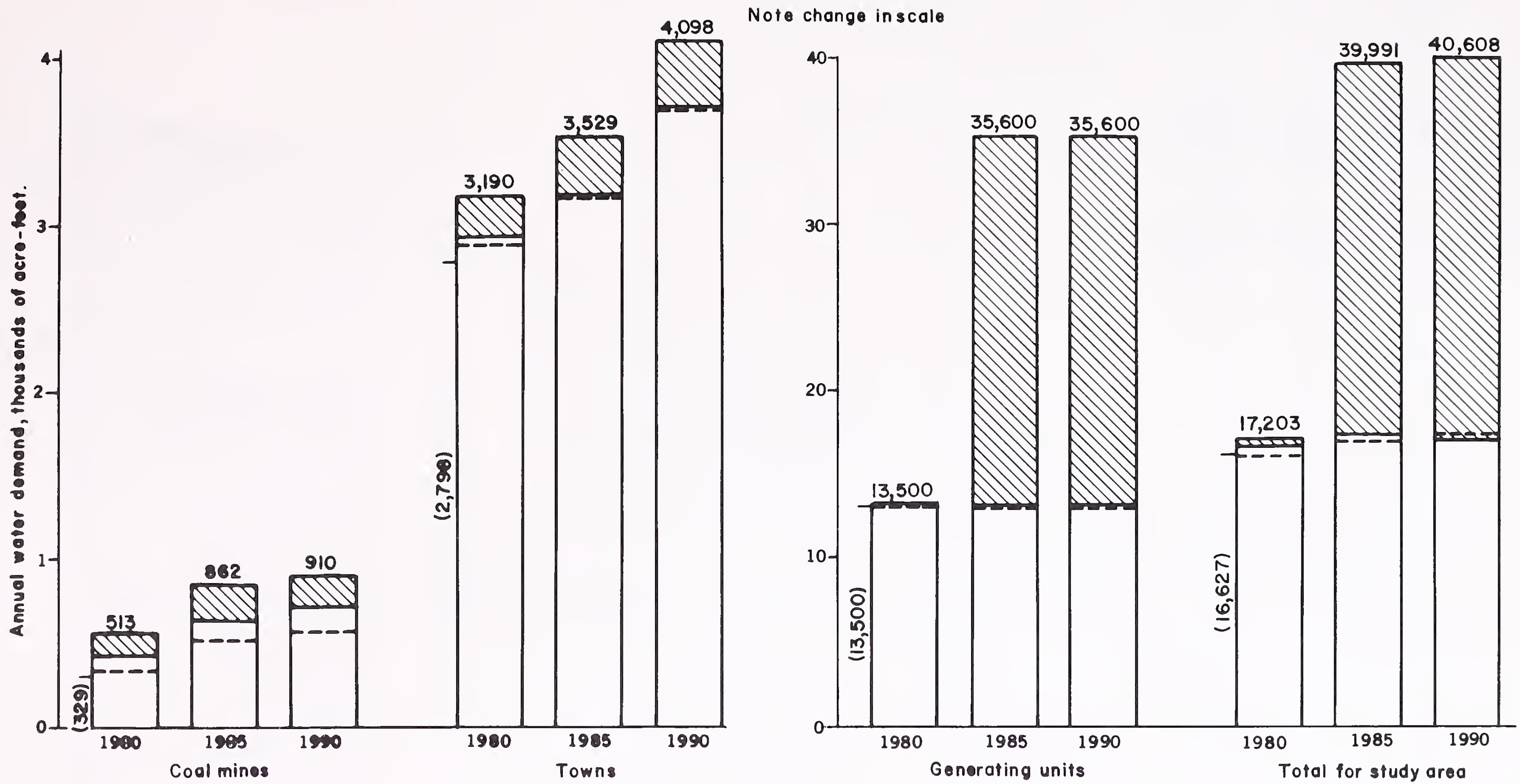


FIGURE IV-1.--Estimated annual consumptive use of water in the study area. Diagonal rules show water use due to the proposed developments. Base of rules shows use if the proposed developments were not approved (baseline production level); dashed lines show use under low production level; (see chapter VIII).

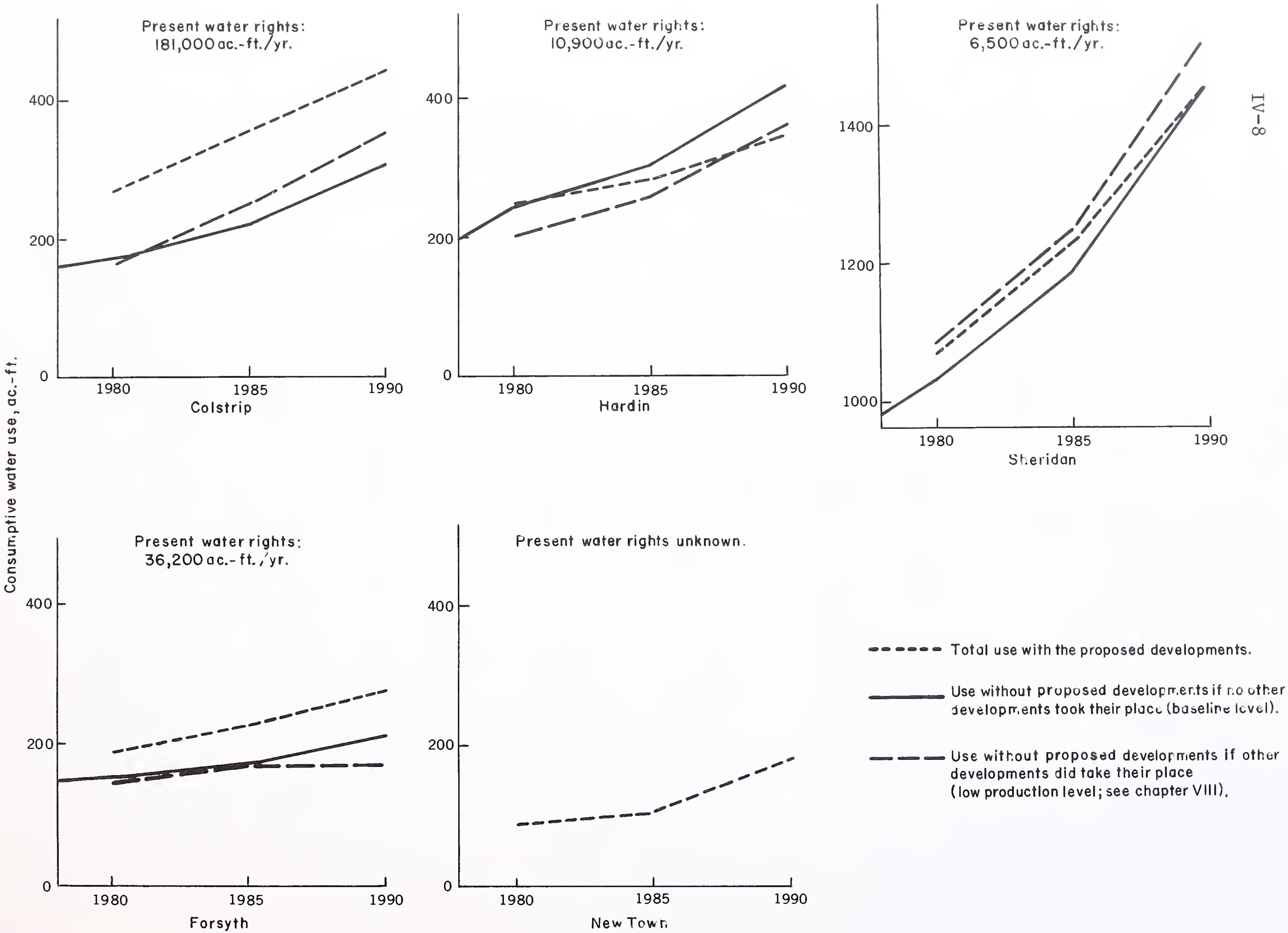


FIGURE IV-2.--Water consumptively used by towns in the study area.

The dissolved-solids load in the Tongue River due to sewage effluent from Sheridan and the new town would be about 195 tons per year by 1990--about 0.07 percent more than the present load. Increased sewage effluent would probably increase ammonia levels in receiving streams for a short distance below the sewage outflow. But the ammonia would dissipate rapidly and reach safe levels for even the most sensitive fish (0.02 mg/L) and for humans (0.5 mg/L).

The leaching of mine spoils would contribute negligibly to the dissolved solids in the rivers of the area. An upper limit for their contributions is approximated below.

The present dissolved load of the Tongue River near its mouth averages 675 tons per day (tpd). The dissolved load at the Montana-Wyoming State line averages 502 tpd, so the load increases by 173 tpd between these stations. The drainage area contributing to the Tongue River between these stations is almost 2.5 million acres. If the dissolved load were uniformly leached from this area, each acre would contribute 0.025 ton of dissolved material per year. That estimate is almost certainly high, because most of the dissolved load probably comes from return flow from irrigation water.

If the same amount of water infiltrated the spoils and if it dissolved twice as much material as from the undisturbed overburden, the concentration of dissolved solids from the mined areas would be twice as high as before mining; that is, there would be an additional 0.025 tons per year (tpy) of dissolved material per acre of disturbed land. This estimate is undoubtedly high--even with proper reclamation, the amount of water entering the spoils tends to be considerably less than the present infiltration to the undisturbed area, and the increase in concentration is probably more often a third to a half the normal concentration of overburden water. An upper limit for the dissolved load in the Tongue River due to leaching of spoils at the proposed mines, therefore, is:

2,175 acres X 0.025 TPY/acre = 54 TPY = about 0.15 TPD

This would be a 0.025 percent increase in the dissolved load of the river. This is substantiated by VanVoast and Hedges (1975) and by FES 77-20.

During mining, the proposed mines would contribute very little sediment to perennial streams, because the mines would be on ephemeral drainages removed from principal perennial streams, and because proposed sediment-control measures appear to be adequate. After bond release, reclamation failures would almost certainly add (perhaps negligibly) to the large quantities of sediment transported during major storms--perhaps several times per century. Increased off-road vehicle trails near the Tongue River Reservoir would increase sediment yield to the reservoir by an unknown--but probably small--amount.

Mining would locally remove shallow coal aquifers and destroy other aquifers in the overburden. Consequent draining of perched aquifers

would slightly lower ground-water levels within a mile or so of the mine. Mining would destroy a few shallow wells near the three proposed mines and a few springs near the Pearl and Spring Creek mines, and it might cause others to go dry. The effect on the base flow of streams near the mines would be negligible--within the limits of accuracy of measurement. The reclamation plans for the proposed mines include provisions for supplying water for the proposed postmining use of the reclaimed area. The total dissolved solids in the water in the mine spoils would be higher than in the undisturbed material before mining. Water from the reclaimed mine pits would migrate to adjacent aquifers.

C. CLIMATE

The proposed developments, along with concurrent mining, would cause small but detectable changes in the quality and quantity of precipitation near the generating units and strip mines, with possible effects hundreds of miles downwind. Particulates and gases would have a relatively minor effect on the local radiation balance, with possible micro-climatic effects on vegetation. The proposed developments would contribute a very small amount to the global increase in atmospheric carbon dioxide.

---

1. Precipitation Quantity

Colstrip units 3 and 4 would slightly increase snowfall near Colstrip and several miles downwind by increasing ice nuclei around which snow would condense. A study in a comparable setting (Agee, 1971) suggests the possibility of as much as 0.25 inch of snow within 5 miles of the units, and the effect might extend as far as 150 miles (VanValin and Pueschel, 1977). This would happen because snowfall in the region depends on the formation of ice nuclei in the "ice-phase" or Bergeron process, and a tenfold increase of such nuclei above background has been observed in the Colstrip plume (VanValin and Pueschel, 1977).

The proposed developments might possibly decrease summer rainfall (probably no more than a few tenths of a percent) within a few hundred miles of the generating units due to the increase in condensation nuclei. This would be most likely when thunderstorms moved upwind toward the pollution sources, or, exceptionally, when storms moved north or south over both the Colstrip and Decker developments. The effect is not likely, because increases in condensation nuclei from the Colstrip plume have not been consistently observed and because this "warm rain" process is not the principal mode of precipitation on the northern Great Plains (University of Wyoming, 1977; VanValin and Pueschel, 1977).

Heat from the generating units would have negligible effects on humidity and only minor effects on the formation of convective clouds. Small clouds would occasionally form over the generating units; larger clouds have been observed, and would be expected, over the mines.

Small particles suspended in the upper atmosphere from the generating units and the mines might slightly increase the frequency of inversions and very slightly reduce convective precipitation (Hobbes and others, 1974; University of Wyoming, 1977). This would happen because the particles would absorb solar radiation, thereby increasing the temperature of the upper air layers and thus increasing atmospheric stability. The effects would be greater near Decker than near Colstrip because the mines near Decker would produce more small particles. The effects would probably be minor during mining and negligible thereafter. If the land surfaces are not stabilized after mining, fugitive dust from these large, scattered tracts could slightly increase the aridity of eastern Montana (Bryson, 1972).

2. Precipitation Quality

Colstrip units 1-4 would probably cause slightly acidic rainfall from local "washout" from the plume, and long-range "rainout" from clouds. Sulfur and nitrogen oxides and possibly chlorine- and fluorine-containing compounds would acidify rain, causing noticeable effects on sensitive vegetation at least 8 miles downwind. (See Vegetation, chapter IV.) Because more precipitation falls in the spring, local acid rain would coincide with the effective growing season, increasing the probability of vegetation damage. However, during heavy rainfall, most common in the spring, the acid would become more diluted (Li and Landsburg, 1978). Increases in the acidity of rainfall could be measured as far as 600 miles from Colstrip. This is uncertain, however, because observed increases in the acidity of rainfall near the existing generating units is inconclusive. (See Climate, chapter II).

3. Radiation Balance

Dust plumes from the mines in a layer 200 to 300 meters thick would decrease mean surface temperature on the order of 0.1°C. This would occur during summer and fall and would have negligible effects.

If the coal mined under the intermediate level were burned in power plants, 182 million tons of CO_2 would be added annually to the upper atmosphere--about 2.5×10^{-6} percent of the global coal-produced CO_2. Man-caused additions of CO_2 to the upper atmosphere, of which coal accounts for about 37 percent, could either increase or decrease ambient earth temperature by absorbtion of solar radiation (Oliver, 1973). Because carbon cycling models speculate that the ocean, the primary CO_2 sink, absorbs only a little over half of all net CO_2 emissions annually, the small increment from coal combustion in the region may be significant.

D. AIR QUALITY

The proposed strip mines and coal-fired generating units would directly and indirectly increase concentrations of particulate and gaseous emissions in Colstrip, Forsyth, Hardin, Sheridan, the new town, and in the clustered mining areas. Carbon monoxide and nitrogen oxide emissions in Colstrip

and Forsyth would increase substantially. Locomotive emissions may cause an odor and particulate dusting problem in these towns. Downwind of the strip mines near Decker, total suspended particulate (TSP) concentrations and dustfall rates would double, although cumulative particulate concentrations in some areas around Colstrip may decrease. State and Federal standards for dustfall and TSP would continue to be exceeded in the vicinity of the mines in the Colstrip and Decker areas. The annual geometric mean TSP concentration in the town of Colstrip may decrease by 14 $\mu g/m^3$ in 1990, when strip mining moves away from the townsite, although coal dust from coal piles and handling facilities would increase. The new town of Spring Creek in the Decker area would experience fugitive dust problems from upwind strip mines comparable to the problems experienced in the Colstrip nonattainment area.

The addition of Colstrip units 3 and 4 (as initially proposed) to units 1 and 2 would have caused violations of the Class I sulfur dioxide (SO_2) standards on the Northern Cheyenne Indian Reservation. After the analysis in this EIS was completed, however, the Montana Power Co. proposed a new scrubbing process using dolomitic lime. The U.S. Environmental Protection Agency (EPA) has tentatively determined that the new process meets the required "best available control technology" (BACT) and will allow units 3 and 4 to meet the applicable prevention of significant deterioration (PSD) requirements. Because of the rapidly-changing circumstances surrounding units 3 and 4, however, the analysis in this chapter focuses on the original proposal. Concentrations of SO_2 downwind from the units but closer to Colstrip may also increase. Minor modification of precipitation patterns and rain chemistry could also occur. (See Climate, chapter IV.) Strip mine dust may have more potential to change local climate than Colstrip units 1-4.

Minor biological (secondary) impacts on vegetation and wildlife from fugitive dust and gaseous emissions from strip mines, as well as from the emissions from Colstrip units 1-4 are possible. (See Vegetation, chapter IV.)

---

1. Emissions from Area Sources

The proposed and projected mines would increase air pollution in five towns in proportion to population increases (table IV-1). Pollution in Colstrip would increase 29 percent; in Forsyth, 23 percent; in Hardin, 17 percent; in Sheridan, 1 percent. Broadus and Hysham would remain unchanged. The new town of Spring Creek would decrease potential population-caused air pollution in Sheridan and Hardin, but would add more air pollutants to the Decker area. Most of the people in this town would be there as a result of the proposed Spring Creek and Pearl mines.

Air pollution emissions in Colstrip and Forsyth would peak in 1982 due to an influx of people for the construction of Colstrip units 3 and 4.

TABLE IV-1.--Estimated gaseous and particulate emissions based on resident population, 1990

Town	Pollutant, tons/year SO_2	CO	NO_x	Hydrocarbons	Particulates
Colstrip--------	519	6,220	1,260	963	444
Forsyth---------	315	3,780	765	585	270
Hardin----------	410	4,920	995	761	351
New town--------	210	2,480	502	384	177
Sheridan, Wyo.--	10,400	33,700	5,930	7,830	7,110

The Big Sky mine expansion would increase air pollution there to a minor degree.

Table IV-2 shows the probable mean annual 24-hour carbon monoxide concentration in these towns during 1985, excluding all sources except population. Sheridan has by far the highest carbon monoxide average.

TABLE IV-2.--Mean annual 24-hour carbon monoxide concentrations

[Parts per million in a 1-square-mile area centered over listed towns]

Town	Carbon monoxide (ppm)
Sheridan, Wyo.-	24.64
Colstrip-------	4.47
Hardin---------	3.57
Forsyth--------	2.83
New town-------	1.34

Particulate and gaseous emissions from internal combustion engines and blasting at the minesites would only affect Colstrip, the new town, and Decker. Nitrogen oxides and carbon monoxide emissions would increase the most (table IV-3). These gases from the mines and from the towns could create the cumulative mean annual concentrations displayed in table IV-4.

2. Mobile Sources

Fuel combustion pollutants and coal dust lost from unit trains would increase with projected coal export from the study area (tables IV-5 and

TABLE IV-3.--1985 emissions from minesite internal combustion engines and blasting

Mine	CO	NO_x	SO_2	HC	HCN	Aldehydes	Particulates
Existing mines							
Rosebud							
Diesel-----	122.9	523.8	39.0	52.8	---	12.1	34.1
Gasoline---	256.5	18.9	0.5	20.3	---	---	2.0
ANFO-------	77.3	65.0	---	---	0.2	---	---
Decker West, East, and North extension							
Diesel-----	189.2	806.6	60.1	81.2		8.7	52.6
Gasoline---	513.0	37.8	1.1	40.5	---	---	4.1
ANFO-------	142.9	120.1	---	---	0.4	---	---
Big Horn							
Diesel-----	78.6	335.2	25.0	33.8	---	7.8	21.8
Gasoline---	3.4	0.3	---	0.3	---	---	---
ANFO-------	27.0	22.7	---	---	0.1	---	---
Ash Creek							
Diesel-----	24.6	107.8	7.8	10.6	---	2.4	6.8
Gasoline---	1.7	0.1	---	0.1	---	---	---
ANFO-------	10.8	9.2	---	---	0.03	---	---
Proposed mines							
Big Sky expansion							
Diesel-----	12.7	54.0	4.0	5.4	---	1.2	3.5
Gasoline---	22.2	1.8	0.1	1.8	---	---	1.6
ANFO-------	1.6	21.1	0.1	---	0.1	---	---
Spring Creek							
Diesel-----	79.3	356.2	26.5	35.9	---	8.2	23.0
Gasoline---	100.3	7.4	0.2	7.9	---	---	0.8
ANFO-------	71.4	60.0	---	---	0.2	---	---
Pearl							
Diesel-----	88.9	379.0	38.2	38.2	---	8.8	24.7
Gasoline---	3.9	0.3	28.2	0.3	---	---	---
ANFO-------	42.6	35.8	---	---	---	0.1	---

TABLE IV-4.--Cumulative mean annual 24-hour carbon monoxide (CO) and nitrogen oxide (NO_x) concentrations (parts per million) in towns downwind from mining

Town	CO (ppm)	NO_x (ppm)	Cumulative sources
Forsyth-------------	3.10	0.37	Locomotive emissions, population
Colstrip------------	4.90	0.87	Locomotive, strip mine emissions, population
Spring Creek--------	1.40	0.21	Strip mine emissions, population

TABLE IV-5.--Range of estimates of coal dust losses from unit trains, (tons/mi²/yr.), intermediate level of coal production

Railway corridor	1978		1990	
	Minimum	Maximum	Minimum	Maximum
East of Forsyth (includes Big Sky mine)-------------	0.7	1,500	1.5	3,400
East of Sheridan, Wyo. (includes Spring Creek and Pearl mines)----------	0.6	1,200	1.4	3,000

IV-6). The railway sector from Forsyth east to the Montana border would be most heavily used. Nitrogen oxides, the most prevalent exhaust from locomotives, would attain emission rates of 40 tons/mile/year in 1980 and 65 tons/mile/year in 1990 along this sector. Coal trains from the Decker area and northern Wyoming mines, although numerous, will not pass through Sheridan, Wyoming (see Transportation, chapter IV); similarly, coal dust loss would be greatest east of Forsyth and east of Sheridan. Figure IV-16 (Transportation) shows the proportion of coal trains from the proposed mines using the routes east from Forsyth and Sheridan.

Air pollutants from trains may decrease the value of property adjacent to the tracks in towns (Small, 1975; Poon, 1978). Coal dust and fuel combustion particulates may become a public nuisance in Forsyth and Colstrip. Gaseous diesel emissions from locomotives could become an odor problem (from the hydrocarbons, acralein and formaldehyde--Elliot and Davis, 1950), and raise ambient concentrations of carbon monoxide and nitrogen oxides (table IV-4).

TABLE IV-6.--Locomotive diesel emissions (lb/mile/year) from coal trains, intermediate level of coal production

		Rail corridor	
		East of Forsyth	East of Sheridan
Hydrocarbons----	1978	15,000	11,600
	1990	33,100	31,200
Nitrogen oxides-	1978	58,800	45,800
	1990	130,400	122,700
Aldehydes-------	1978	890	690
	1990	1,970	2,000
Organic acids---	1978	1,100	860
	1990	2,500	2,300
Particulates----	1978	3,960	3,080
	1990	8,770	8,260
Sulfur oxides---	1978	9,060	7,060
	1990	20,100	18,900
Carbon monoxide--	1978	20,700	16,100
	1990	45,900	43,200

3. Emissions from Colstrip Units 1-4

a. Gaseous emissions

With controls proposed at the time of writing, Colstrip units 3 and 4 would increase total emissions of SO_2, NO_x, fluorides (HF), and carbon dioxide (CO_2) (table IV-7). All gaseous emissions would increase by 68 percent. A new scrubber system proposed by the company has tentatively been certified by the EPA to meet requirements for best available control technology and the PSD increments on the Northern Cheyenne Reservation. Units 1 and 2 would periodically exceed the revised EPA emission standard for SO_2 and the NSPS for NO_x. (See Future Environment, chapter II.) Although the revised SO_2 standard does not now apply to units 1 and 2, it would apply to units 3 and 4. Units 3 and 4, as originally proposed, would periodically violate both standards; it is not known whether emissions under the new controls would violate the revised NSPS.

b. Particulates

Since the design efficiency of particulate control for units 3 and 4 would be the same as those presently in operation, the emission rate would be 0.034 lb/10^6 Btu). The NSPS of 0.1 lb/10^6 Btu and the Montana emission standard of 0.14 lb/10^6 Btu would not be violated. Total annual

TABLE IV-7.--Total gaseous emissions from Colstrip units 1 through 4, burning area C coal 80 percent of the time at full capacity (tons/yr)

[Source: EVST Laboratory, 1978]

Emission	Units 1 and 2	Units 3 and 4	Units 1-4
SO_2-----------	25,000	53,010	78,010
NO_x-----------	17,480	37,100	54,580
Fluorides-----	0.51	1.02	1.53
CO_2-----------	5,600,000	11,200,000	16,800.000

particulate emissions would increase from about 900 tons/year to 2,900 tons/year, varying with the ash content of the coal. Similarly, trace metal emissions would also increase, although these estimates may be conservative. (See ch. II, Air Quality.) Table IV-8 shows the 1976 prediction of trace element emissions, the emissions observed last year, and a 1979 prediction based on the 1976 observations.

TABLE IV-8.--Predicted and observed trace element emission rates from the Colstrip generating units

[Source: Mont. Dept. of Natural Resources, 1976; O'Toole and others, 1977]

Trace element	Predicted (1976) (tons/year)			Observed March 15-17, 1976 (tons/year)	Predicted (1979) (tons/year)	
	1 & 2	3 & 4	1-4	1 & 2	3 & 4	1-4
Arsenic-----	1.32	2.92	4.24	1.66	3.72	5.38
Fluorine----	9.04	20.50	29.54	16.02	35.88	51.90
Copper------	1.01	2.22	3.23	---	---	---
Mercury-----	0.45	1.04	1.49	2.01	4.50	6.51
Selenium----	0.28	0.59	0.87	1.45	3.49	5.05
Antimony----	0.24	0.56	0.80	0.19	0.43	0.62
Vanadium----	0.80	1.81	2.61	---	---	---
Zinc--------	13.21	29.19	42.40	---	---	---

4. Air Quality Modeling--Colstrip Area

a. Sulfur dioxide (SO_2), Colstrip units 1 through 4

SO_2 concentrations on the Cheyenne Indian Reservation from units 1-4 cannot be predicted exactly, but ground concentrations of SO_2 on elevated terrain would be well in excess of the Class I increment based on controls originally proposed by the company. Both the 3-hour and 24-hour standard would be violated, according to mathematical predictions developed by Williams (1978).

Units 3 and 4 would more than double SO_2 emission rates from those associated with units 1 and 2. Ground concentrations of SO_2 during plume strikes would not decrease and the plume cross section (therefore area affected) would increase. If the atmosphere around the units were not saturated with SO_2, the ground concentrations would also increase as much as twofold.

The area now impacted most heavily by the plume is within a 4-mile radius of the units, particularly on the buttes north and south of Colstrip. The future impacted area is unknown. Trace elements, nitrogen oxides, and sulfur oxides could injure vegetation and wildlife downwind of Colstrip units 1 through 4. (See Vegetation, chapter IV.) Acid rain from the washout of nitrogen and sulfur oxides from the power plant plume may also damage vegetation. (See Climate and Vegetation, chapter IV.) Particulates from the power plants could alter local snowfall patterns, and ice-phase summer rainfall. (See Climate, chapter IV.)

b. Total suspended particulates (TSP), Colstrip area, 1985-90

Annual geometric mean concentrations of TSP would range from 1 to 250 $\mu g/m^3$ above background over nearly 300 square miles around Colstrip (fig. IV-3). Violations of the annual geometric mean would be confined to the vicinity of the mines. Within these areas, which include the highway, TSP concentrations in 1985 would be twice those in 1978 (fig. II-23). Downwind concentrations would not change significantly.

The Big Sky mine would increase annual geometric mean TSP concentrations in the town of Colstrip by 1 $\mu g/m^3$ (fig. IV-4). This increase would occur in a nonattainment area, although it would not significantly add to pollution in the town.

Fugitive dust emissions from the Big Sky and Rosebud mines would overlap in an area of several square miles southwest of Colstrip and east of the Big Sky mine (fig. IV-3). TSP measurements in this area in 1985 would be 10 $\mu g/m^3$ greater than in adjacent, non-overlapping areas. This is 10 $\mu g/m^3$ less than 1978 projections, largely because both mines would be moving farther west in 1985. By 1990, the mines would be still further apart, and the zone of overlap still less, although the total area affected by TSP would be greater (fig. IV-5).

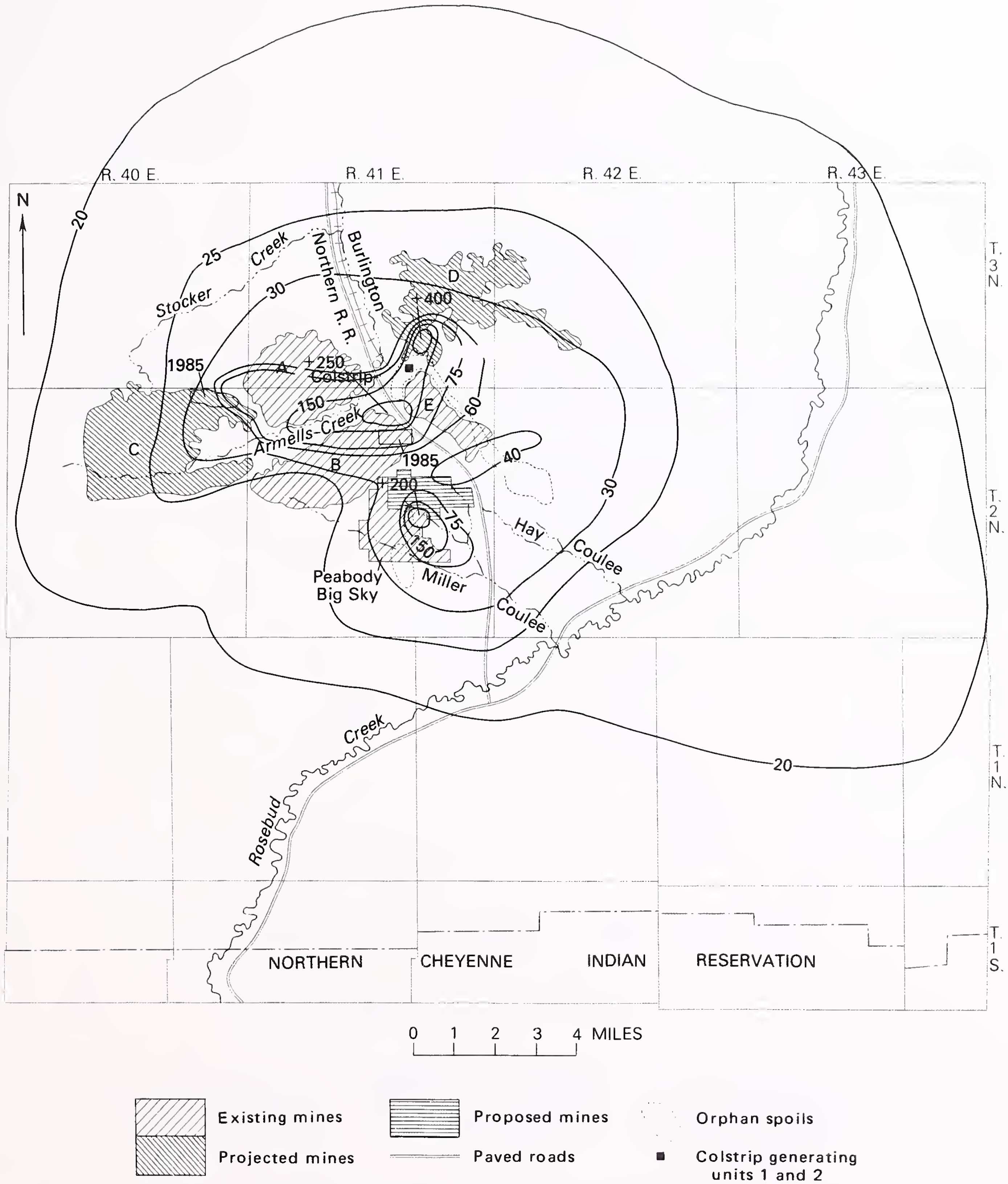


FIGURE IV-3.--Annual geometric mean TSP ($\mu g/m^3$) in the Colstrip area during 1985. Background of 20 $\mu g/m^3$ is plotted.

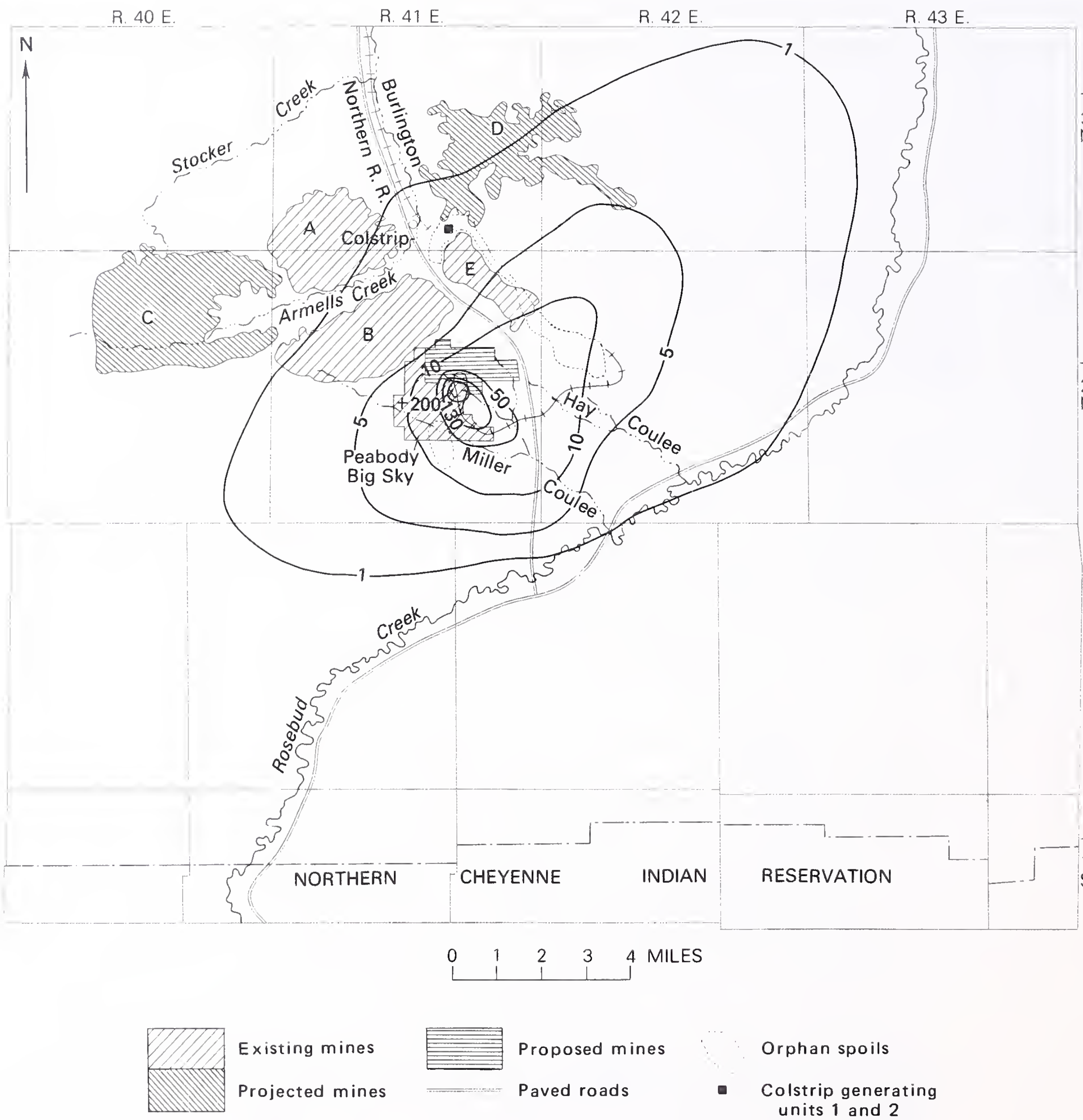


FIGURE IV-4.--Annual geometric mean TSP ($\mu g/m^3$) from the Big Sky mine during 1985. Background is not plotted.

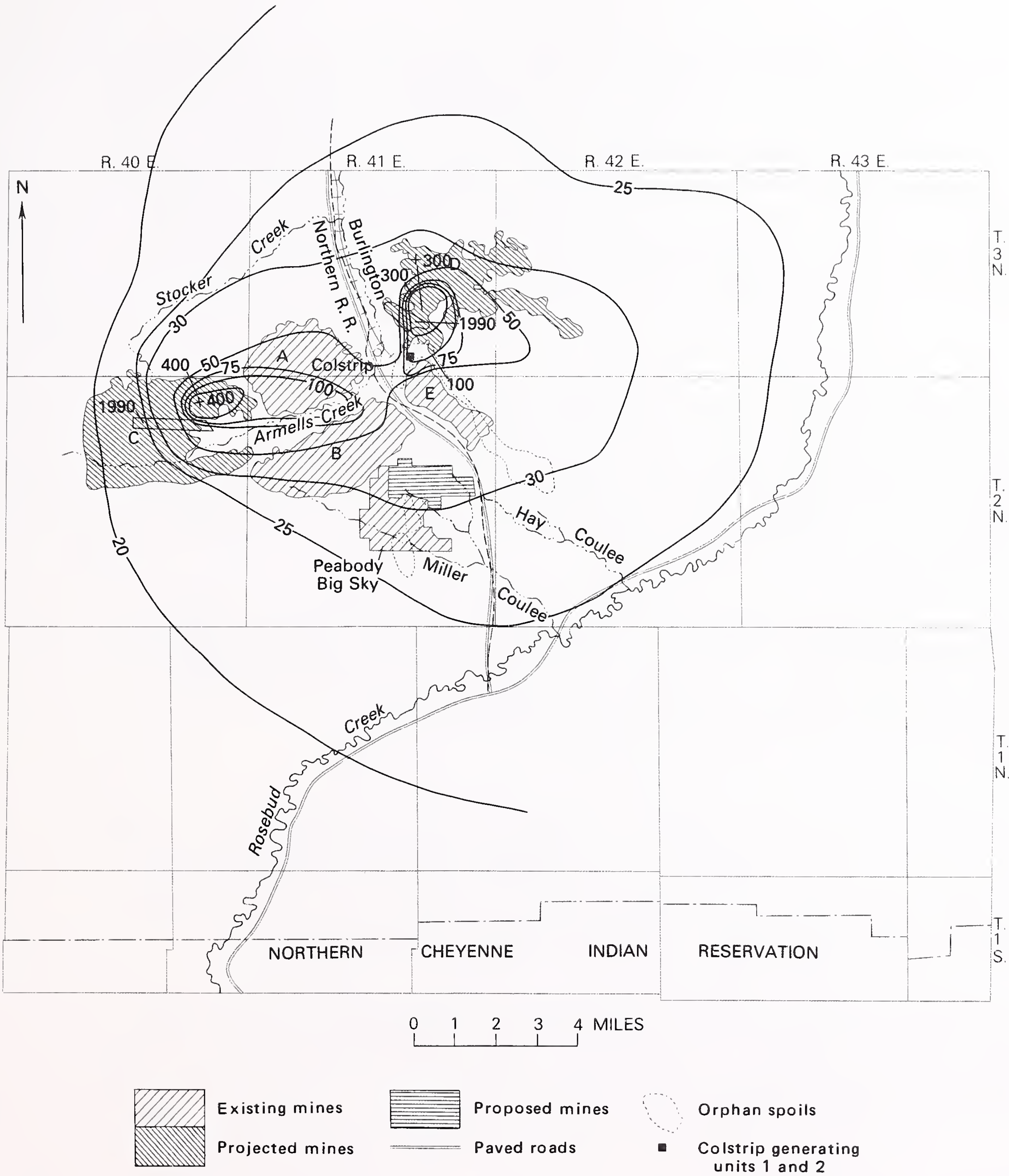


FIGURE IV-5.--Annual geometric mean TSP ($\mu g/m^3$) from the Rosebud mine during 1990. Background of 20 $\mu g/m^3$ is plotted.

In 1985, the annual geometric mean TSP concentration in Colstrip would be about 55 $\mu g/m^3$, about 10 percent above the 1978 concentration. In the mobile-home courts north of the powerplants, however, concentrations would exceed 400 $\mu g/m^3$, seriously violating standards; they would be largely due to the coal-handling facilities for Colstrip units 3 and 4. By 1990, the Rosebud mine will have moved far enough west and also downwind of Colstrip into Area D, so that concentrations in the town would decrease by 25 percent to an annual geometric mean of 41 $\mu g/m^3$ (fig. IV-5). The increased population of Colstrip would increase 1970 particulate emissions by about 280 tons in the town area, perhaps increasing concentrations, but probably not exceeding standards.

c. Dustfall, Colstrip area

Dustfall (dust deposited on soil, vegetation, or water surfaces) indicates total dust dose to the biological environment. Dustfall rates would range from 1 to more than 100 tons/mi^2/month over nearly 200 square miles around Colstrip in 1985 (fig. IV-6). Most violations of the dustfall standard (15 tons/mi^2/3-month) would occur inside the 10 ton/mi^2/month isopleth, which would roughly correspond to the mine boundaries.

As mining in the Colstrip area becomes less clustered in 1990 (Big Sky may have expanded to the southwest by that time) the impacted area would increase (fig. IV-7); dustfall would decrease, however, notably in the area east of the Big Sky mine, which in 1978 appeared to have elevated TSP concentrations and dustfall rates.

5. Air Quality Modeling, Decker Area

In the Decker area, the clustering of several mines, their ancillary facilities, and the new town in the Tongue River drainage would aggravate air quality impacts. Pollutants generated in this drainage-dominated airshed would tend to be trapped, because inversions may be frequent, lasting perhaps all day in the winter, and because air flow is predominantly along the drainage. (See Air Quality, chapter II.)

The dust model crudely predicts dust fallout and ambient dust concentrations (figs. IV-8 and IV-9) based on meteorological data at the Pearl weather station 10 miles west of the Tongue River. The model does not predict worst-case air pollution, which is likely caused by drainage effects and the relative aridity of the area.

a. Total suspended particulates (TSP), Decker area

In 1985 the area impacted by mine generated dust pollution will increase from 500 square miles to 820 square miles (fig. IV-8). The Spring Creek mine and Decker North extension together would increase the impacted area by almost 30 percent, and would nearly double the concentrations of TSP as far as 25 miles downwind from the Decker mines. The

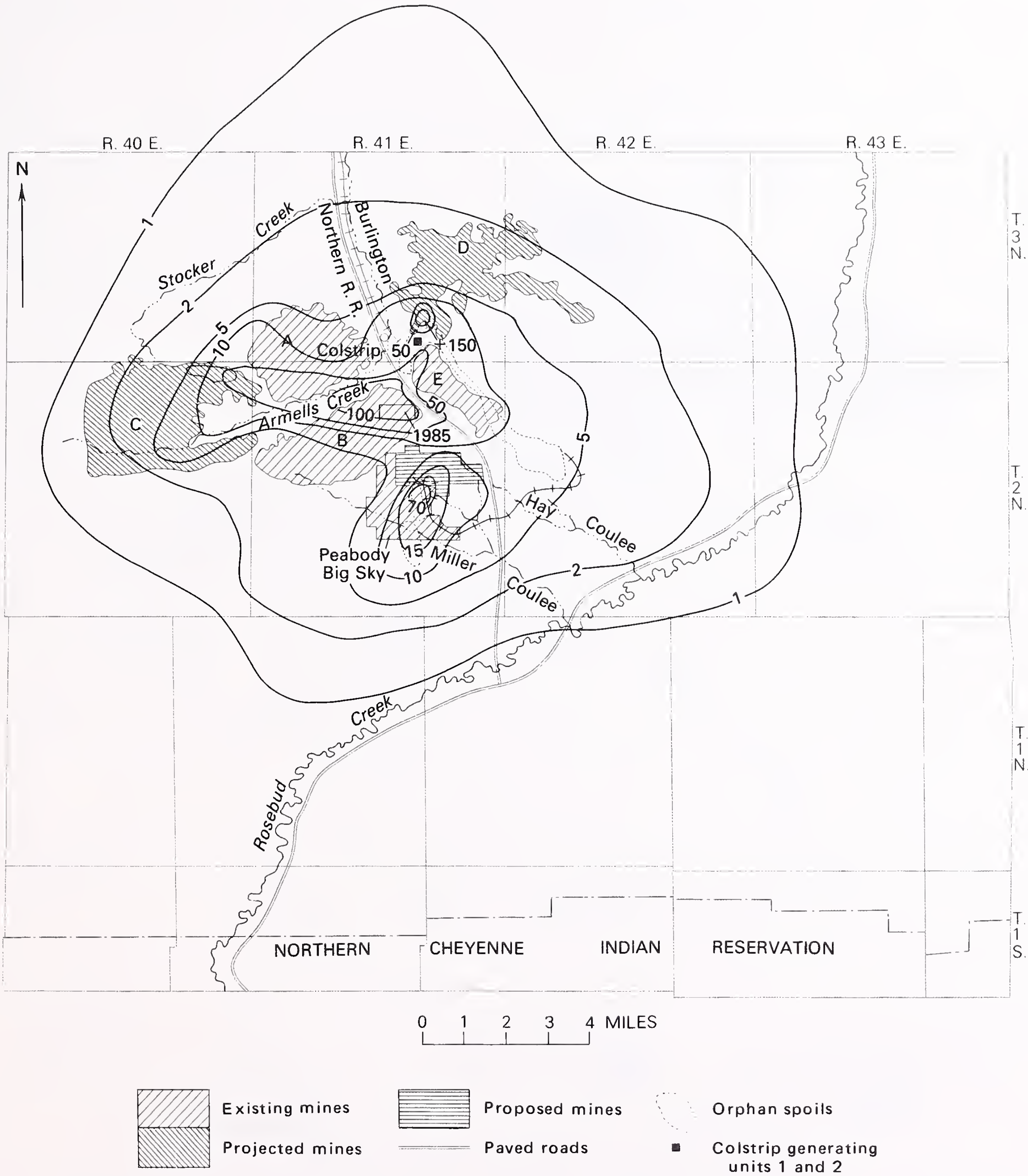


FIGURE IV-6.--Annual mean monthly dustfall (tons/mi^2/mo) in the Colstrip area during 1985. Background is not plotted.

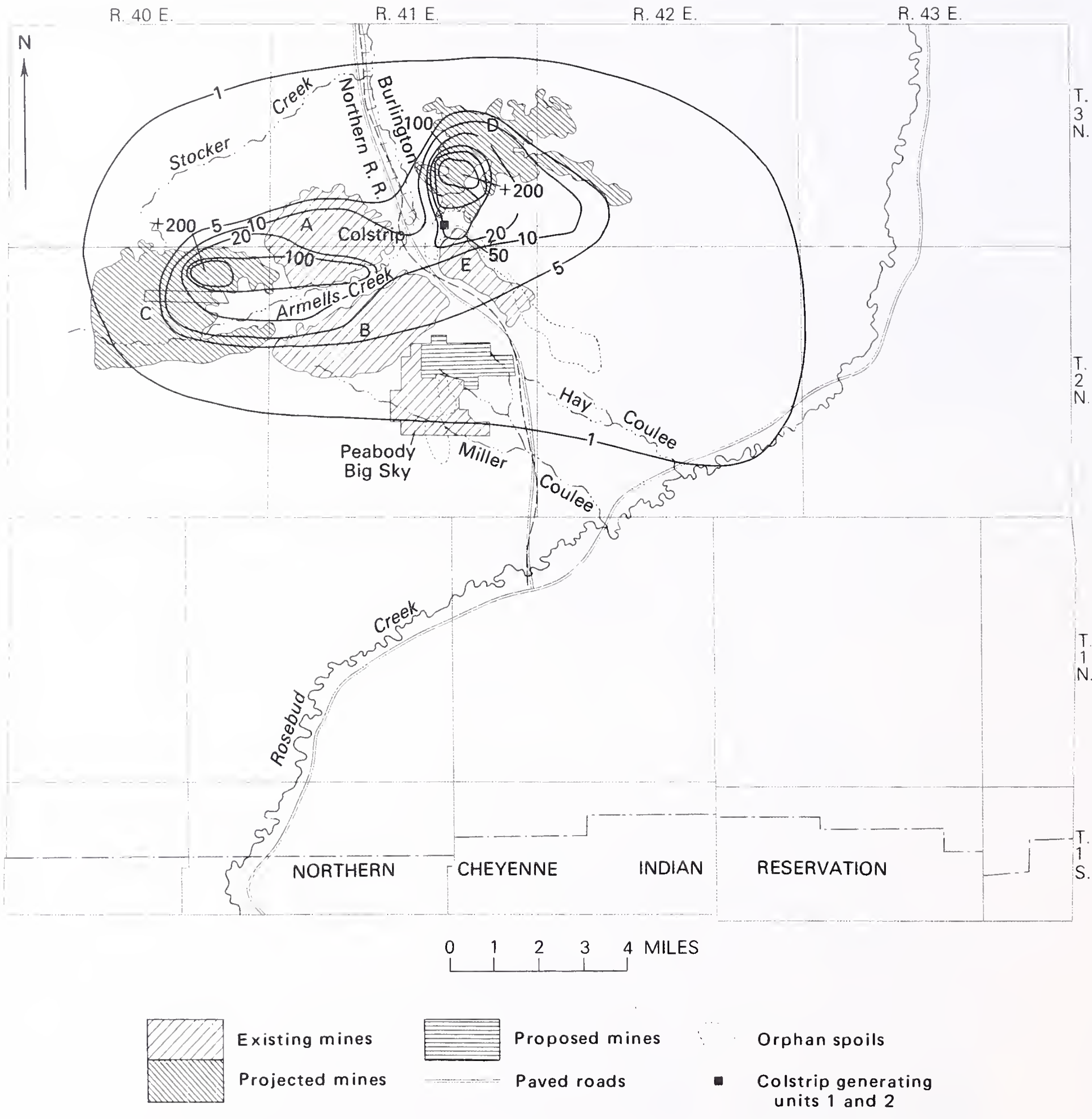


FIGURE IV-7.--Annual mean monthly dustfall (tons/mi^2/mo) from the Rosebud mine during 1990. Background is not plotted.

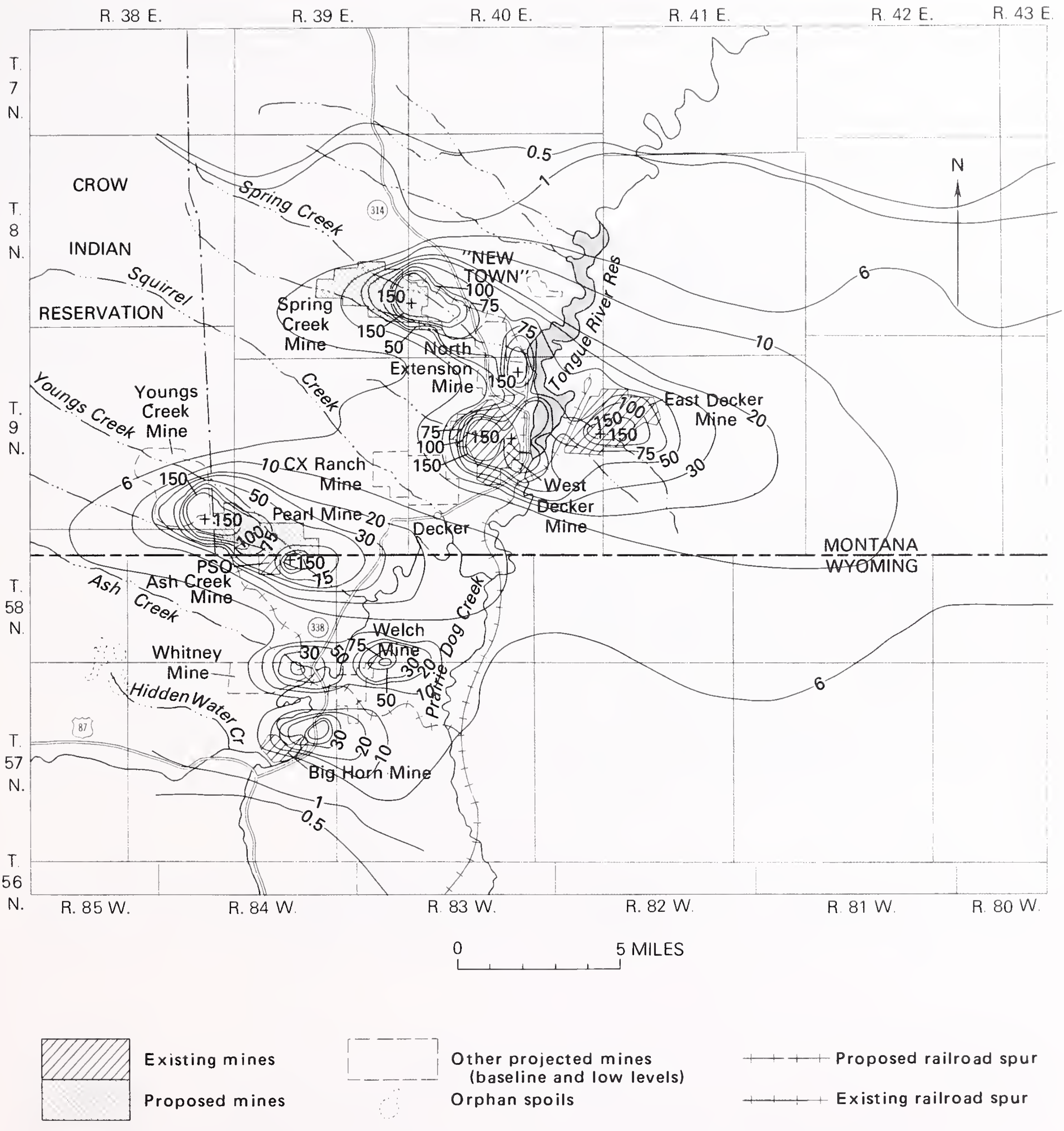
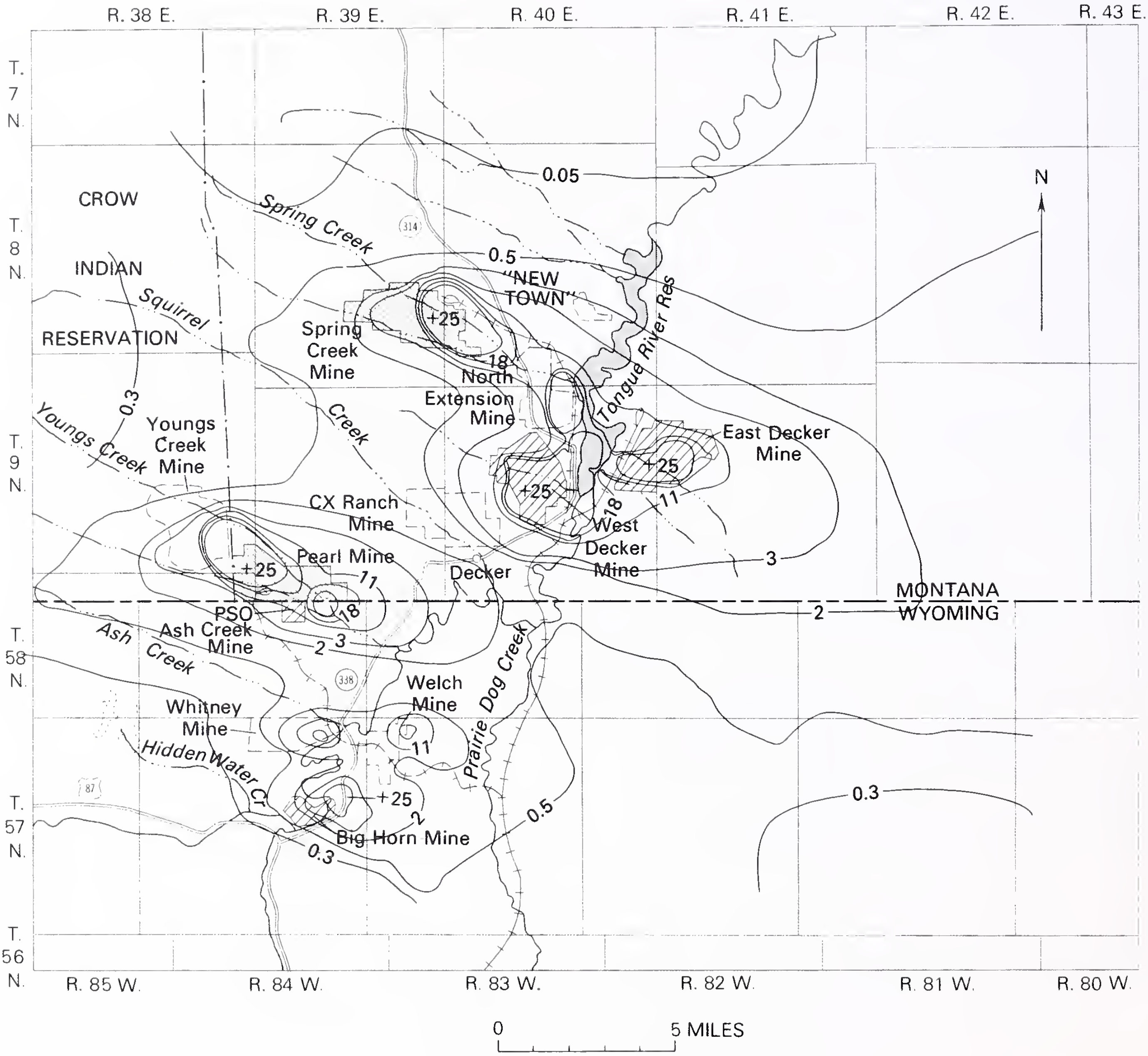


FIGURE IV-8.--Annual geometric mean TSP ($\mu g/m^3$) in the Decker area during 1985. Background is not plotted.



	Existing mines		Other projected mines (baseline and low levels)		Proposed railroad spur
	Proposed mines		Orphan spoils		Existing railroad spur

FIGURE IV-9.--Mean monthly dustfall (tons/mi^2/mo) in the Decker area during 1985. Background is not plotted.

standards for annual geometric mean for TSP would be violated within the 50 $\mu g/m^3$ isopleth 1 to 3.5 miles downwind of the mine boundaries.

The Spring Creek mine alone would increase annual geometric mean concentrations near the West and East Decker mines by at least 10 $\mu g/m^3$. TSP concentrations also would double downwind of the Pearl and Ash Creek mines (fig. IV-8).

Montana Highway 314 would pass between or downwind of nine strip mines in the Decker area (fig. IV-8). Esthetic visibility for motorists would be degraded. The Spring Creek mine would contribute to intermittent hazardous reductions of visibility along this highway.

The population in the new town would generate 155 tons of particulates annually (table IV-1). Added to the particulates from the mines, the annual geometric mean within the new town would be about 40 $\mu g/m^3$. This would be somewhat less than the TSP concentrations experienced in Colstrip.

b. Dustfall, Decker area

Dustfall rates in the Decker area would range from 15 tons/mi^2/month to more than 25 tons/mi^2/month over an area of roughly 630 square miles (fig. IV-9). This would be an increase of 110 percent since 1978 (fig. II-29).

The model predicts that the Tongue River Reservoir would act as a sink for more than 25 tons per month of particulates--roughly 1 ton per day or more than 300 tons annually. This would be an insignificant volume; however, it could affect water quality.

Impacts on soil insects, surface algae and lichens, and vegetation would most probably be confined to the 11 ton/mi^2/month increment (fig. IV-9). Reclamation areas would receive the most dust, with possible adverse effects on vegetative productivity and on reclamation. (See Vegetation, chapter IV.)

E. SOILS

Reclaimed soils at the proposed mines would support good initial plant growth, but their ability to support diverse, self-sustaining vegetation over the long term is not assured. Due to the drastic alteration of soils, reclaimed areas would require specialized management until well after bond release. (See section d below.)

The three proposed mines would disturb a relatively small portion of the region. (See Land Use and figure IV-14.) Colstrip units 3 and 4 would disturb only a small area, but emissions from the units could adversely affect soil productivity and vegetative quality over a large area, perhaps as much as 60 square miles.

Reclaimed soils on all three mines would support adequate initial growth of vegetation on most of the mined area, but erosion and sedimentation related to the postmining topography of the Big Sky mine would locally prevent adequate growth. The release of nutrients following mining, along with artificial fertilization, would promote rapid growth for the first few years after mining, aided by supplemental irrigation in case of drought.

The ability of the reclaimed soils to support diverse, drought-resistant vegetation after about the first 5 years is less certain. Depending on the nature of the soils and regraded overburden, the postmining topography, the climate, and the level of management, vegetative productivity would range from near premining potential to well below premining potential. Within 3 to 4 decades, with proper management and favorable soil conditions, some areas would have moderately diverse plant communities. Mined areas with unfavorable soil conditions or poor management would regress to plant communities dominated by undesirable, weedy species lacking the quality or resistance to drought necessary for long-term stability and for supporting the required levels of livestock and wildlife.

The plan for the Big Sky mine expansion proposed at the time of writing does not realize the potential for reclamation inherent in the soils and other parameters of the minesite. Initial vegetative establishment would not be adequate to meet reclamation requirements. The proposed mine plan would leave a number of relatively large (up to 10 acres) depressions in the reclaimed surface. These depressions would accumulate runoff and sediment eroded from overly long and locally oversteepened slopes. During seasons with high precipitation, the accumulated sediment and water would turn to mud, which would be a hazard to cattle, and possibly to deer and antelope. Use of the reclaimed surface would be severely restricted and thus would not meet reclamation requirements. The depressions would eventually become saline from evaporation of ponded water, compounding the problem by further reducing plant growth. The mine plan has been revised and will be evaluated in the FES on the Big Sky mine. (See DES 78-51.) Under a mine plan that fully utilized the reclamation potential of the minesite, reclamation success would be more likely than at the two other proposed mines.

Reclaimed soils at the Spring Creek mine (as originally proposed) would allow successful establishment of vegetation, but would develop problems with growth and succession later, probably before bond release. Under the current wetter-than-normal climatic conditions which have prevailed since before 1970 (Climate, chapter II), the anticipated problems would require longer to develop. Similarly, drier-than-normal conditions would accelerate the process. These problems would not limit grazing as severely as at the Big Sky mine expansion but would still reduce productivity below potential and increase susceptibility to drought.

Sodium in the overburden, especially in the eastern half of the minesite, would eventually migrate to the surface and cause poor soil conditions which would interfere with plant growth. (This problem has been corrected in the revised plan.) The overburden in the eastern half

of the minesite has an average sodium-adsorption-ratio (SAR) of 29.6, which exceeds the maximum acceptable level of 12, established by the Montana Department of State Lands. This sodium would move upward and would affect the "topsoil"[1] within the life of the mine, probably within 3-10 years, unless the mitigating measures described in chapter VIII are employed. Upward vertical movement of 5 to 6 feet through nonsodic topsoil has been documented under similar conditions in reclamation surfaces in North Dakota (Sandoval, 1978) in less than 3 years. Sodium in detrimental amounts has been observed to contaminate 12 inches of topsoil in 3 years (ARS and NDAES Staff, 1977). Conditions at Spring Creek vary only slightly from those at the experimental sites.

Sodium causes dispersion of clay particles and has a worsening influence on soils with increasing amounts of clay in the soil. Sodium-dominated spoils and soils show poor structural development, high bulk densities, crusting, and restricted infiltration and permeability (Sandoval and Gould, 1978; Buckman and Brady, 1972). These problems all reduce the amount of water available to plants, which is generally a limiting factor for plant growth and long-term reclamation success.

The proposed Pearl mine plan shows considerable care given to topsoil salvage and placement, coupled with a well-designed reclamation surface. Initial vegetation would be successfully established, and the probability of reclamation meeting legal requirements is as great as present technology will allow. Because precipitation at the site is marginal to arid (about 12 inches per year) and the clay content of the overburden is high (37 percent), water infiltration, percolation, and storage would be reduced. This would unavoidably increase the susceptibility of vegetation on the reclaimed site to drought. There are a few minor problems, notably elevated nickel and molybdenum, which have a low probability of becoming long-term problems. This mine would be subject to the same unavoidable problems which would affect any strip mine in semiarid lands. Moderately heavy (clay loam) soil and equally heavy overburden would probably limit rooting depth in most areas, which would limit the availability of water during drought.

1. Long-Term Reclamation Problems

The proposed and projected mines would be subject to some reclamation problems which are due more to the nature of the soil than to the method of reclamation. Such problems are found to varying degrees in all strip mines in the semiarid West. These include loss of structure and particle dispersion, compaction, reduction in soil organic matter, and rapid release of previously unavailable plant nutrients. The severity of these impacts

---

[1]"Topsoil" is a common term with no exact meaning. Here it is used to denote any material derived from natural soil profiles suitable for or capable of supporting plant growth and meeting Montana Department of State Lands guidelines for salvage.

depends on the nature of the land to be mined and the mining plan; the site-specific EIS's discuss these problems in more detail.

Reclaimed soils would not redevelop structural characteristics comparable to the original soil for decades (in the case of less developed soils) to many centuries (for the more developed soils) or not at all for Aridisols, which probably formed under a different climate.

The success of revegetation on these drastically disturbed soils over the long term (decades or centuries after bond release) is not assured, since there is not enough information to determine what conditions and practices are necessary for long-term success.

Natural vegetative succession in old fields in the northern Great Plains is slow, requiring many decades to reestablish a climax plant community (Olson, 1973). Mined lands would be more drastically disturbed than old fields and thus would probably take as long or longer to return to approximately premining conditions, even with careful management. Fifty-year-old spoils at Colstrip support some near-climax plant communities, particularly at the Cape Oliver site (William Shafer, oral commun.). Prospects for long-term maintenance of this more diverse, developed vegetation are fairly good. Other old spoils at Colstrip show vegetation still in the initial stages of succession, with minimal chances of withstanding drought or sustained intense grazing. Some unknown difference in the physical and/or chemical properties of the soils, together with environmental influences such as seasonal weather, microclimate, and seed sources most likely accounts for the differences in development.

If conditions at the proposed minesites were carefully studied before and during mining, it might be possible to understand and correct deficiencies in vegetative establishment and development as they occurred. (See chapter VIII.)

a. Water availability

The principal key to reclamation success is the availability of water to plants. Mining would cause loss of soil structure, pore continuity and volume, and root channels. These effects, combined with particle dispersion and surface crusting, would reduce water infiltration and make less water available for storage and plant use. An exception may be found in coarser textured materials (loamy sand, sandy loam) (Schafer and others, 1978), but such materials are not common on existing or proposed mines in the region.

When soluble salts are brought into the rooting media from deeper zones of accumulation, osmotic potential is increased, which decreases the amount of water for plant use. Higher bulk density would increase the mechanical resistance to root expansion and decrease the soil volume from which a plant may extract water. Compaction during grading and/or sodic overburden spoils could develop an impermeable interface between

"topsoil" and spoils, severely restricting soil water percolation and rooting depth (Gary Wendt, oral commun.; Gilley and others, 1976). This effect would be most pronounced at the Spring Creek and Pearl mines where the impermeable interface would be within 20 inches of the surface. The Big Sky mine has sufficient topsoil available to avoid this problem if the material is salvaged.

The composition of plant communities can also affect soil water availability (Schafer and others, 1978). Rapid growth by cool-season (spring) plants reduces soil water available to warm-season (summer) plants, reducing diversity and long-term reclamation success. Soil water is almost completely depleted each year, forcing the vegetation to rely on spring precipitation to recharge the soil every year. Drought resistance is reduced.

b. Nutrients

Nutrient limitation, except for phosphorus, and to a lesser degree, nitrogen, usually does not develop until after a period of growth if at all. Under law, initial deficiencies must be corrected at the time of seeding. With a maximum of five growing seasons' experience with reclamation at active surface mines in the northern Great Plains, the nutrient status of revegetated mined lands cannot be fully described. Initial studies and observations indicate that early productivity may be dramatically high. (See Vegetation, chapter IV).

Reclamation materials in the northern Great Plains usually have reduced plant-available phosphorus (Sandoval and others, 1973) and nitrogen (ARS-NDAES, 1977), and increased zinc (Hinkley and others, 1978). Molybdenum-induced copper deficiencies are less well known (Erdman and others, 1978) but may affect cattle through their forage, especially legumes. Calcium:magnesium ratios in subsoil and spoil solutions frequently are less than 1, a situation which could create nutritional problems, although none have been reported to date.

c. Soil chemistry

Reclaimed soils and vegetation could develop problems from trace element or mineral imbalances. Problems of this sort have not been documented in the region due in part to limited experience with reclamation. The following discussion of potential problems is based on a 1978 survey by Zasoski (report on file at the Department of State Lands, Capitol Station, Helena, Montana 59601).

Soil extracts at existing and proposed minesites in the region frequently have Ca:Mg ratios less than 1, which is comparable to soils derived from serpentine materials. Such soils often support only specialized plant species and ecotypes (Proctor and Woodwell, 1975). Surface soils in the region appear to have favorable Ca:Mg levels, probably as a result of long-term mineral cycling. Native and introduced species adapted to a normal Ca:Mg environment may not grow well in the

subsoil and overburden where this ratio is unfavorable. There are no reports to date that this situation has resulted in problems in either vegetation or animals, but the situation has not been specifically studied.

An additional magnesium-related condition is the possibility of developing a magnesium solonetz soil. This soil condition could form where magnesium concentrations exceed calcium in irrigation or ascending ground water. Such soils have poor physical behavior with problems similar to those of sodic soils (Bolt and Bruggenwert, 1976). Magnesium solonetz soils could also be formed in areas where salts could be deposited at the surface by capillary water rise and evaporation (Sherman and others, 1962).

High levels of toxic trace metals could become available to plants by a variety of means, including: exposure of properly buried toxic materials through gully formation; extraction by deep-rooted plants; improper disposal of toxic materials; and weathering of minerals, releasing previously unavailable toxic elements, e.g., oxidation of metal sulfides to sulfates which could significantly alter extractability and plant availability.

d. Management difficulties

Management of reclaimed land at the Spring Creek and Pearl mines would be especially difficult, due to the moderately heavy textures of the soil and overburden (R. J. Lorenz, Agricultural Research Service, Mandan, North Dakota, oral commun.). This problem would exist even with the best reclamation technology (Murray, 1978; National Academy of Sciences, 1974).

The ability of mined land to support grazing at a given level depends not only on total forage production (the traditional measure), but also on soil texture, structural development and strength, plant community composition, geomorphic stability, and in some cases, the chemistry and mineralogy of the soil and overburden. The resilience of the soil would be reduced because of the lack of structure and reduced organic matter. The impacts of occasional overgrazing would be much greater on mined land than on native range, and could cause long-term reductions in productivity. Management practices which are acceptable on native range would not necessarily be acceptable on reclaimed lands. Overgrazing would seal the surface, and reduce soil water availability to plants by reducing infiltration and increasing runoff and erosion.

Optimal grazing intensity and timing could contribute to nutrient cycling and structural development by reincorporating plant litter into the soil, encouraging later-season growth by reduction of cool season plant material, and reducing evapotranspiration rates. Initially, it would be more difficult to distinguish between acceptable and unacceptable levels of management on mined lands than on native range. Methods to determine the best level of grazing or other uses are discussed in chapter VIII.

F. VEGETATION

Impacts on vegetation would be of moderate significance during mine life; they would be of unknown but possibly high significance after mine abandonment. The approximately 23,000 acres of land that would be disturbed by 1990 by all mining-related development would not support vegetation comparable in overall quality to premining conditions for decades after reclamation. At the time of mine abandonment, there would probably be adequate vegetative communities on the minesites, but in the long term, there is no assurance that the vegetation that ultimately evolved would support anticipated uses for wildlife and livestock grazing.

No known threatened or endangered species would be impacted by the proposed mines.

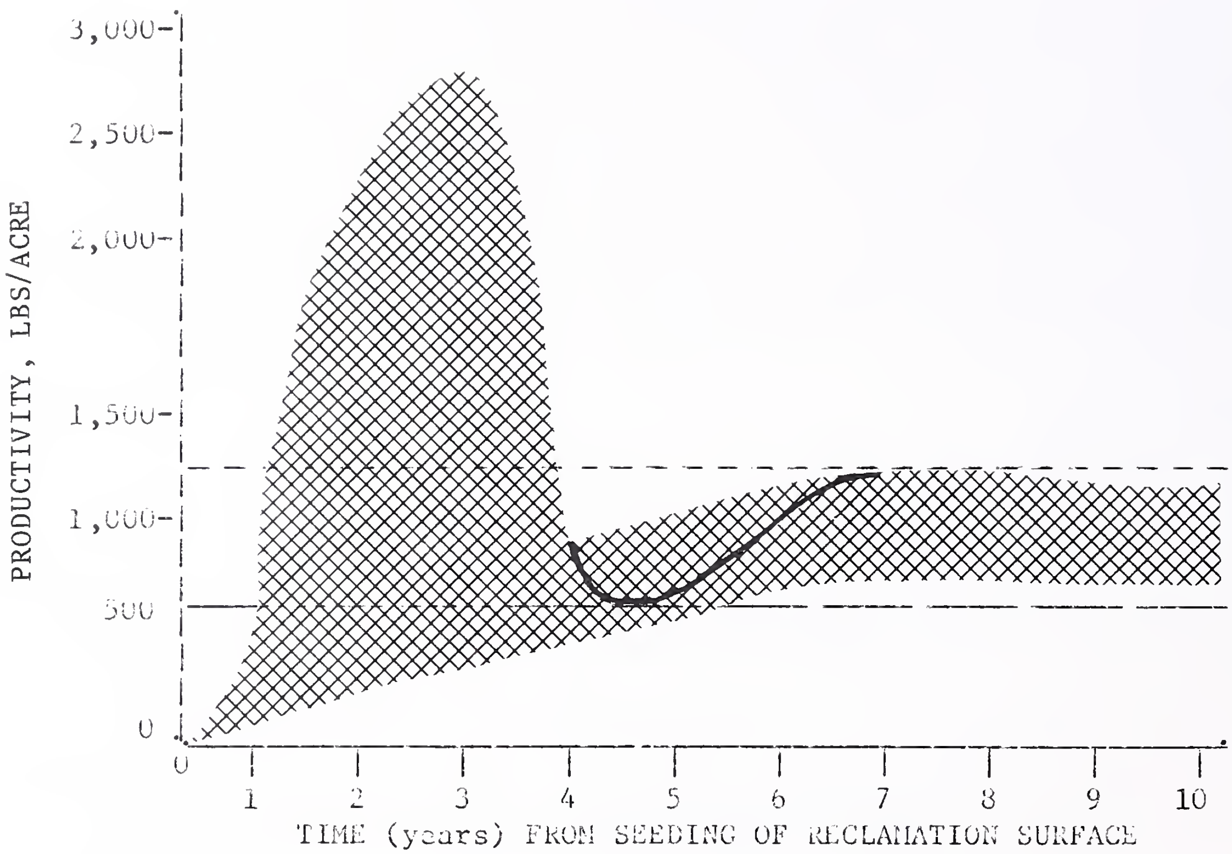
---

1. Vegetative Establishment and Productivity

The most serious impact on vegetation on areas disturbed by mining would be the long-term elimination of the natural vegetation mosaic and species diversity on an estimated 23,000 acres, of which about 3,000 acres would be on the three proposed mines. This loss would greatly reduce the capability of these disturbed areas to provide suitable wildlife habitat and watershed protection. Present technology has failed to demonstrate an ability to permanently reestablish ponderosa pine, Rocky Mountain juniper, deciduous trees, and many shrubs and forbs.

Postmining vegetation would usually provide a higher quantity of livestock forage than exists now for several years or longer following initial establishment. Maintenance of this level of productivity over the long term, especially during drought, is not assured. Over the long term, livestock carrying capacity would probably be at or slightly below premining potential under optimal management (fig. IV-10). Improper seeding or grazing management would most likely reduce the carrying capacity from its premining condition.

The plants which initially thrive would be cool season, highly competitive species which grow rapidly in the spring and early summer. They would use seasonally available water (Schafer and others, 1978), nutrients released during handling of the soil, and the fertilizers applied at time of seeding. After 3 to 5 years, one or more soil nutrients would become depleted because they would accumulate in undecomposed plant material. Initial high productivity would usually be followed by sudden, extreme drops (DePuit and others, 1978; Dennis Hemmer, Montana Department of State Lands, oral commun.). Eventually, nutrients stored in plant litter would be returned to the soil, and productivity would stabilize at levels at or near the potential productivity before mining (fig. IV-10). Under sound management, postmining productivity may exceed levels actually achieved before disturbance perhaps by 50 percent or more. Such increases are sometimes due in part to heavy grazing on the minesites before disturbance, reducing the natural productivity (Dennis Hemmer, DSL, oral commun.).



- - - - - - Assumed premining potential productivity, averaged for both precipitation and topographic variation.

_____ ____ Recorded forage production level--premining survey at Big Sky and Spring Creek mines.

FIGURE IV-10.--Potential range of forage production on reclaimed mined land with optimal topsoil salvage, handling, and management. Cross-hatched area shows range of forage production. Solid line shows dip in productivity observed by DePuit and others (1978) following peak at 3 years.

Even though reclamation must comply with State and Federal regulations (chapter III), compliance alone does not insure success: many required and proposed reclamation methods are vague, and post reclamation management can greatly influence vegetative production.

For the first several years after reseeding, reclaimed areas would have a relatively uniform composition of grasses, forbs, legumes, and weedy species. Seed present in the topsoil at the time of its removal would contribute only slightly to the new vegetation, since the viability of most of the seed would be lost during stockpiling and redistribution of topsoil. Topsoil placed directly without stockpiling would produce a much greater percentage of growth from salvaged seeds and plant materials. Invading weeds could be relatively dense the first few years, but would decline as perennial species crowded them out.

The reclaimed vegetation would be more susceptible to drought (Soils, chapter IV) and might have to be reseeded. Revegetation probably would fail in small areas throughout the reclaimed surface, which would require reseeding and other remedial treatments. These spot failures would be caused by sheet and gully erosion of redistributed topsoil, primarily along regraded highwalls, and by chemical and physical problems of the topsoil.

Within one or two decades after reseeding, heterogeneous vegetation patterns would probably begin to appear in favorable areas. Plant succession would depend on soil texture, nutrient status, seed sources, and precipitation in a way that is not yet fully understood (National Academy of Sciences, 1974). Possible techniques for refining the management of plant succession are discussed in chapter VIII. By the time a given mine would be abandoned, successional patterns and trends would probably be recognizable in the earlier reclaimed areas.

Several plant species requiring specialized micro-environments would be greatly reduced on the reclaimed surfaces for the long-term, unless reclamation technology makes substantial advancements. Without the necessary advances, ponderosa pine would probably be lost as a self-sustaining population on the proposed minesites. Because ponderosa pine reproduces infrequently and grows slowly, it is not known what moisture, soil, and bedrock conditions would be needed for successful reestablishment. The necessary conditions would probably not exist on the reclaimed surfaces except in small areas. Further, the success of establishing this species in areas of marginal moisture (such as in the Decker area) has not been demonstrated. Optimal climatic conditions for ponderosa pine establishment appear to be infrequent in the region. Rocky Mountain juniper would also be lost for the long-term, but would be more likely to become reestablished since it is less dependent on specific site conditions.

The success of reclamation may be highly dependent on future climatic conditions. Severe droughts can be expected in the area, and there are indications that recurring dry years comparable to the droughts of the 1930's may return within 1 to 2 decades. (See Climate, chapter II.)

Heavy rainstorms during periods of dry weather would cause considerable erosion.

In the past, periods of favorable climate led many people to overestimate the agricultural productivity of the area. The droughts which followed caught people unprepared, losing crops, cattle, sheep, and with the duststorms, the topsoil itself (Lomasson, 1947; Coffey, 1978). The ranching operations which survived the droughts of this century have adapted to the vagaries of climate. There has not been enough experience with mined-land reclamation to learn what procedures and standards are necessary to ensure the long-term survival of self-sustaining vegetative communities. Current reclamation efforts have taken place during a period of unusually favorable precipitation. (See Climate, chapter II.)

2. Hydrologic Impacts on Vegetation

Mining would not directly disturb much riparian vegetation. Should destruction of alluvial aquifers occur, thereby eliminating perched water tables, deciduous trees depending on them would probably be lost until surface waters are reestablished. This could happen at the Pearl mine, and would probably occur if Spring Creek were expanded to the original 10 mty plan. (See Hydrology, chapter IV.) Other species such as the riparian shrubs would likewise be lost for perhaps several decades until necessary moisture conditions are created and natural encroachment of these species occurs.

3. Air Quality Impacts on Vegetation

a. Sulfur dioxide (SO_2) and nitrogen oxides (NO_x)

Sulfur dioxide from Colstrip units 3 and 4 could slightly reduce conifer, grass, and lichen productivity in areas of repeated plume strikes. Likely impact areas are within a 4-mile radius of the units and on high terrain of the Northern Cheyenne Indian Reservation. Expected SO_2 concentrations from units 1-4 cannot be predicted exactly, but if they were twice the maximum hourly concentration from units 1 and 2, ponderosa pine seedling productivity could well be significantly reduced, based on studies of red pine by Constantinidou and others (1976). Injury to ponderosa pine needles from SO_2 and NO_x, already observed within a 4-mile radius of the units (Air Quality, chapter II) would continue or increase. Short term exposures to SO_2 and NO_x in ambient concentrations as low as those recorded downwind of units 1 and 2 causes minor changes in plant function (Biscoe and others, 1973; Unsworth and others, 1972; White and others, 1974).

Average concentrations of these pollutants recorded downwind of the units have been much higher than concentrations shown to reduce photosynthesis in alfalfa, barley and oats (Bennett and Hill, 1974); to reduce grain weight (Guderian, 1977); or to disrupt natural grassland ecosystems (EPA, 1978). Damage to lichens from SO_2 alone is unlikely, but in combination with NO_x, fluorides, and acid rain, lichens would be threatened locally.

Periodic faulty explosive blasts from strip mines (not ordinarily expected) would emit sufficient NO_2 to cause acute injury to vegetation several miles downwind.

b. Acid rain

It is not known whether the plume from Colstrip units 3 and 4 would cause acid rainfall, but if it were to occur (see Climate), it would coincide with the effective growing season, and could cause widespread though not dramatic decreases in vegetative productivity. The alkaline soils of the area could well offset the effect of acid rainfall. The most probable damage would be needle deformities in ponderosa pine (Gordon and Tourangeau, 1975); decreased productivity in lichens (Sheridan and Rosenstreter, 1973); decreased nitrogen fixation in lichens and small soil organisms (Dennison and others, 1976); and leaching of nutrients from plant leaves (Whittaker and others, 1974).

c. Particulates

Dust from the mines and particulates from the generating units would accumulate in lichen (Jenkins and Davies, 1966), possibly posing a threat to wildlife foraging on those plants. Deposition of trace elements on the soil surface could inhibit soil nitrification (Liang and Tabatabai, 1978). Accumulations of dust near the mines could slightly change microclimates, but any resulting loss in vegetative productivity would not be severe. (See Climate, chapter IV.) Coal dust on plant and soil surfaces could change plant communities by locally eliminating sensitive species (Auclair, 1976; Rao, 1971). Dustfall could cause further basal necrosis in ponderosa pine needles near Colstrip; this effect and the existing damage may be from the generating units or from nearby strip mines (Gordon and others, 1978).

Dust from sodic overburden at the Spring Creek mine could decrease the number and species of lichens (Gilbert, 1976) and vascular plants (Brandt and Rhoades, 1972), as well as decreasing shoot length in deciduous shrubs and trees (Brandt and Rhoades, 1973) and needle length in conifers (Darley, 1966).

4. Other Indirect Impacts on Vegetation

Reclaimed and native vegetation near the proposed mines and facilities would be impacted to varying degrees by disturbances such as dust, off-road vehicle travel, and fire. However, these impacts would be short-term, and would essentially cease with abandonment of a mine.

In addition to causing dust, increased off-road vehicle travel would compact soils locally. This compaction would severely reduce vegetation productivity in vehicle tracks, thereby inducing additional rill and gully erosion. Rolling reclaimed surfaces may be attractive to off-road vehicle (ORV) users. Soil compaction from ORV's would restrict moisture infiltration, inhibiting vegetative growth. Vehicles would crush or

uproot plants, reducing the effective growing period, and often causing failure in plants to bloom or reproduce (Bury and others, 1976). There would be about an 8-percent reduction in grain yield on clayey soils with normal farm traffic and substantially greater reduction with additional tractor use (Eriksson and others, 1974).

During mine life, there would be a slight increase in fire frequency due to mining-related activities; however, most fires would probably be restricted to a few acres because of fire-fighting equipment at the minesites. Fire danger on reclaimed land would be at least as high as on undisturbed areas, and probably higher, due to accumulated plant litter.

G. WILDLIFE

Impacts on wildlife would range from negligible to severe. Some wildlife species would be severely affected for at least the life of the mines and probably several decades after mining. The uses of wildlife for hunting and viewing within the Colstrip and Decker subregions would be substantially lowered for decades. Reclaimed land would be less diverse in species composition, vegetation, slope, soils, and topography, and many wildlife species would be adversely affected by long-term habitat alteration. Populations of antelope, mule deer, and sage grouse would be substantially lowered in the vicinity of the proposed mines, and with the added impacts of existing and projected mines, regional populations would be noticeably lowered. Mining near Decker would disrupt the most important block of sagebrush habitat in the region, thus reducing populations of species depending on this habitat. (See Wildlife, chapter II.)

Colstrip units 3 and 4 would adversely affect relatively stationary wildlife species (those with small home ranges) to an unknown, but probably not severe, degree. The new town would compound the effects of the Spring Creek and Decker mines, especially on antelope. The town would cause a permanent loss of habitat. Roaming pets, off-road vehicle use, hiking, etc. would affect utilization of habitats, perhaps as much as 1 to 2 miles from the town.

No threatened or endangered species would be adversely impacted by the proposals. Elimination of cliffs at the Big Sky and Spring Creek mines would reduce potential nesting sites for the endangered peregrine falcon. Prairie dog towns near Colstrip and on the Pearl lease area (potential habitat of the black-footed ferret) would not be lost.

Effects on big game movement would probably last only as long as the mines are active. The loss of habitat on the mine sites would last decades and possibly centuries after mine abandonment with current reclamation capability. Reclamation of native plants comparable in species diversity to unmined land has not been demonstrated in the region. Establishment,

survival, and reproduction of ponderosa pine and shrubs (particularly sagebrush) has also not been demonstrated, and species which depend on these habitats (Wildlife, chapter II) would be most affected. In addition, the existing topography, including sandstone cliffs and talus slopes, would not be recreated.

1. Antelope

The most serious impacts would be on antelope, particularly around the Spring Creek mine, and to a lesser extent around the Pearl mine. These two mines and other projected developments would probably cause the loss of 20 percent or more of the high count of antelope observed in the winter of 1977-78 in the Decker subregion, mainly due to loss of carrying capacity of the subregion's three major winter ranges.

Perhaps 300 or more antelope would be lost during the first winter comparable to the severe winter of 1977-78. During following severe winters there would probably be smaller direct losses. The Spring Creek mine and railroad, the North Decker mine, and the new town would essentially eliminate crucial areas of the Spring Creek winter range, particularly those used during the severe winter of 1977-78 (fig. II-35). The scoria pit and the first 10 years' mining at Spring Creek would eliminate two crucial areas; the railroad and mine pit would interrupt movement between crucial areas, especially at the east end of the permit area. The Decker North Extension would eliminate another crucial area. The new town would extend into and probably preclude use of a fourth crucial area.

The 300 to 400 antelope (maximum counts) observed on the Spring Creek range in the past few years (U.S. Fish and Wildlife Service, 1978) would probably be displaced to Tanner Creek or other adjacent winter ranges. Those ranges are assumed to be at or near carrying capacity. (See Wildlife, chapter II.) There would be heavy losses in a severe winter, because the forage would have been reduced by above-capacity use during previous milder winters. The reduction in carrying capacity on the Tanner Creek winter range and the interrupted use of the Spring Creek winter range would be most pronounced during mining. After mining, some of the undisturbed crucial areas might again be used. The two crucial areas disrupted by mining at Spring Creek and the area disrupted at North Decker, however, would have very low carrying capacity until shrubs (particularly sagebrush) were reestablished. Carrying capacity would slowly increase as forage production and diversity of reclaimed areas increased. Whether it would attain premining capacity cannot be determined, because the effect of topographic changes on carrying capacity is not known. The crucial area west of the new town would largely be unused as long as the town remains.

The proposed railroad spur to the Pearl mine would bisect a crucial area in the third major winter range. Trains would probably hit an unknown number of antelope, particularly during severe winters when the animals are concentrated on that area. The impact would last as long as

mining continued in the Pearl area, and would present a continual hazard. If the railway were fenced with antelope-tight fence, the entire crucial area might be lost because of restricted antelope movement.

If a new coal mine is developed to the west of the Pearl mine on the Crow Indian Reservation, use of a fourth major antelope winter range would be essentially eliminated. This winter range would only be slightly affected by the Pearl mine. The 100 antelope (maximum count) recorded on this range during the winter of 1977-78 could well be lost, although these were the only antelope observed on this range since 1975.

2. Grouse

There would be locally severe effects on sage grouse, primarily from the Spring Creek mine, which contains an important wintering area and lek-nesting complex. The impacts would be long-lasting, because sagebrush, on which sage grouse are almost totally dependent, is difficult to reestablish, and the grouse appear strongly attached to traditional leks and nesting areas.

The Big Sky mine would have less serious effects on sage grouse since it would disturb only marginal habitat (ECON, 1977). The Pearl mine would disturb general sage grouse habitat, but would not destroy any known leks or nesting areas, and thus would not be expected to cause a substantial local loss of grouse.

Sage grouse are not widely distributed in the region. The loss of habitat from the proposed mines, along with habitat lost from other mines (Wildlife, chapter II) would restrict their range to an unknown degree.

Sharptailed grouse are more numerous and well-distributed in the region than sage grouse, and also appear to be less sensitive to disturbance. The loss due to the proposed mines would not seriously reduce sharptail populations. The Big Sky mine would not eliminate any sharp-tailed grouse leks. The Spring Creek and Pearl mines would eliminate two leks which, along with the loss of brushy coulees which provide important winter food and cover, would be the most severe impact on sharptails from mining.

3. Deer

Regional losses of mule deer habitat would not be serious. The Big Sky mine would disturb part of an important mule deer winter range, but the primary-use area of that winter range appears to be north of the mine (Schwarzkoph, oral commun., 1979) and thus would not be disrupted.

The revised Spring Creek mine would have negligible effects on mule deer, since it would not disturb the high-use parts of the winter range (north-facing timbered slopes and breaks to the south of the mine). The small part of the winter range which would be lost would not greatly

reduce the overall carrying capacity of the range. Potential expansion of mining within the lease area (which may be proposed again in the future) would, however, infringe on some key-use portions of the Spring Creek-Squirrel Creek winter range, causing an unknown but probably substantial reduction of winter carrying capacity, and losses of animals during severe winters.

The Pearl mine would interfere with the use of Little Youngs Creek as a wintering area and as a possible fawning area. Mining would also disrupt seasonal deer movement along Youngs Creek and Little Youngs Creek in spring and summer. The projected Youngs Creek mine to the west of the Pearl mine would only slightly disrupt use of this winter range. The loss to deer populations from these mines---a maximum of about 35--would be small, considering the size of other deer herds in the Decker subregion.

The proposed mines would have little effect on white-tailed deer since the riparian habitat on which the deer depend would not be destroyed. The Pearl mine might disturb an aquifer feeding Little Youngs Creek, which would reduce vegetation along the stream and limit use of the area by whitetails. Even if this were to happen, the effect would be small, although it would possibly compound the recently observed decline in whitetail numbers on the Pearl site.

4. Raptors

The Spring Creek mine would have the greatest effect on raptors. A pair of golden eagles which hunt on the Spring Creek site might well be displaced to adjacent hunting territory, if available. Mining at Spring Creek would remove cliffs which are potential nest sites for the prairie falcon, (a species of special interest in Montana) and, possibly, for the endangered peregrine falcon. The loss of these sites would not be severe since other local sites would still be available. Sandstone cliffs and ledges at the Big Sky mine, which provide nesting sites and hunting perches for falcons, might be lost. A great horned owl nest, two possible prairie falcon nests, a possible red-tailed hawk nest, and an old golden eagle nest have been identified in the Big Sky expansion site. Disturbance from mining could result in abandonment of active nests.

All three mines would reduce populations of cottontails, which are important prey for golden eagles and red-tailed hawks, but proposed and projected mining would probably not lower the prey base enough to cause population declines. Smaller raptors such as marsh hawks and kestrels would benefit from the temporary increase in small rodents on reclaimed minesites.

5. Other Animals

The proposed mines would reduce populations of some songbird species, but the overall loss would be small: only a small part of the region would be disturbed, and songbirds are numerous throughout the region.

The proposed mines would eliminate unknown numbers of small mammals and invertebrates, and the populations which would be reestablished after reclamation would not be as diverse as before mining.

Some direct losses of reptiles and amphibians would occur from mining in the region. Disruption of rock outcrops would eliminate reptile denning sites. Losses would not likely be significant because of the regional abundance and distribution of reptiles and amphibians.

Adverse impacts on fish in the Tongue River and its reservoir would not be significant, due to the relatively small amount of sediment expected from the mines under proper management. Increased population would increase fishing pressure and harvest, especially in the reservoir and immediately below the dam.

H. SOCIOLOGY

The proposed developments would contribute to a continuation of the social impacts begun during the past decade. Social impacts from all concurrent developments in Colstrip and Forsyth would probably be comparable in significance to those experienced during construction of Colstrip units 1 and 2 in the mid-1970's. The new town in southern Big Horn County would probably experience impacts similar to those in Colstrip following the opening of the Rosebud mine in 1968. Impacts in Sheridan would probably be less severe than those of the past few years, because the new town would draw many of the newcomers away from Sheridan. In addition, experience with growth has given these communities greater ability to deal with change. Because of this it is likely that impacts would be far less than in some other rural western boomtowns such as Gillette and Rock Springs, Wyoming.

1. Population

The proposed developments (mainly generating units 3 and 4) would account for about half of the rapid population growth in Colstrip and Forsyth. The proposed Pearl and Spring Creek mines would account for about one-third of the growth in the new town. If the new town were not built, those mines would account for about one-quarter of the growth in Sheridan.

The population of the six-county study area would increase from about 59,800 in 1979 to about 82,000 in 1990--about 5,700 more than without the proposed developments. (See figure IV-11.) Practically all

FIGURE IV-11.--Population changes in the six-county study area, 1940-90.

the population growth due to the proposed developments would be in the new town in Big Horn County, and in Colstrip and Forsyth in Rosebud County. The proposed developments would account for about 35 percent of the 1978-90 population growth in Big Horn County and about 48 percent of the 1978-90 growth in Rosebud County.

The Pearl and Spring Creek mines would slightly affect populations in the rural communities of Decker, Four Mile, and Kirby; the Big Sky expansion and the Colstrip generating units would affect Rosebud and Ashland. The proposed developments would negligibly affect populations in Custer, Powder River, and Treasure Counties. Similarly, they would probably have only moderate effects on Sheridan County: although many of the workers at the Pearl and Spring Creek mines would probably live in the new town, they would probably use facilities and services in the Sheridan urban area. If the new town were not built, they would account for about 25 percent of the 1978-90 growth in Sheridan.

Impacts in Rosebud County would be due almost totally to the proposed generating units. They would be moderately significant, although relatively short term: populations would increase very rapidly in Colstrip and Forsyth from 1979 to 1982 (fig. IV-12). In both towns, growth would be about twice as rapid as without the proposed developments, and the most rapid growth would occur about 2 years earlier. Populations in both towns would decline gradually from about 1982 to about 1984, and then grow slowly. Colstrip's population would more than double between 1979 and 1982, from about 3,000 to about 6,200--about 2,000 more than without the proposed developments.

Studies of a number of rapidly growing western towns (HUD, 1976; ERDA, 1977; Gilmore, 1976; NIMH, 1977) indicate that "boomtown" growth may be defined as growth which exceeds the ability of a community to take full advantage of the benefits of that growth or avoid its adverse impacts. When growth is so rapid that it outpaces even intensive efforts at management, or if the impacts of that growth are not adequately predicted in advance, social problems will follow. Communities which have been held as examples of adverse "boomtown" growth, such as Gillette and Rock Springs, Wyoming, did not have much advance knowledge of the extent or rapidity of growth on which to base their plans.

Within the study area, McQuiston (1979) found a serious lack of knowledge among key public officials of possible rates and effects of growth. Officials responsible for community and county planning were unaware of likely rates of growth and expressed disbelief that such rates could occur. The lack of advance knowledge and planning will hamper efforts to accommodate or manage social impacts related to growth.

Growth in Colstrip would be rapid enough to cause problems even with good planning; the growth rate would approach the limits of prior experience as exemplified in Page, Arizona, which experienced a combined recreation and energy boom (fig. IV-12). Forsyth and the new town would not grow as fast as Colstrip, but they would still grow faster than

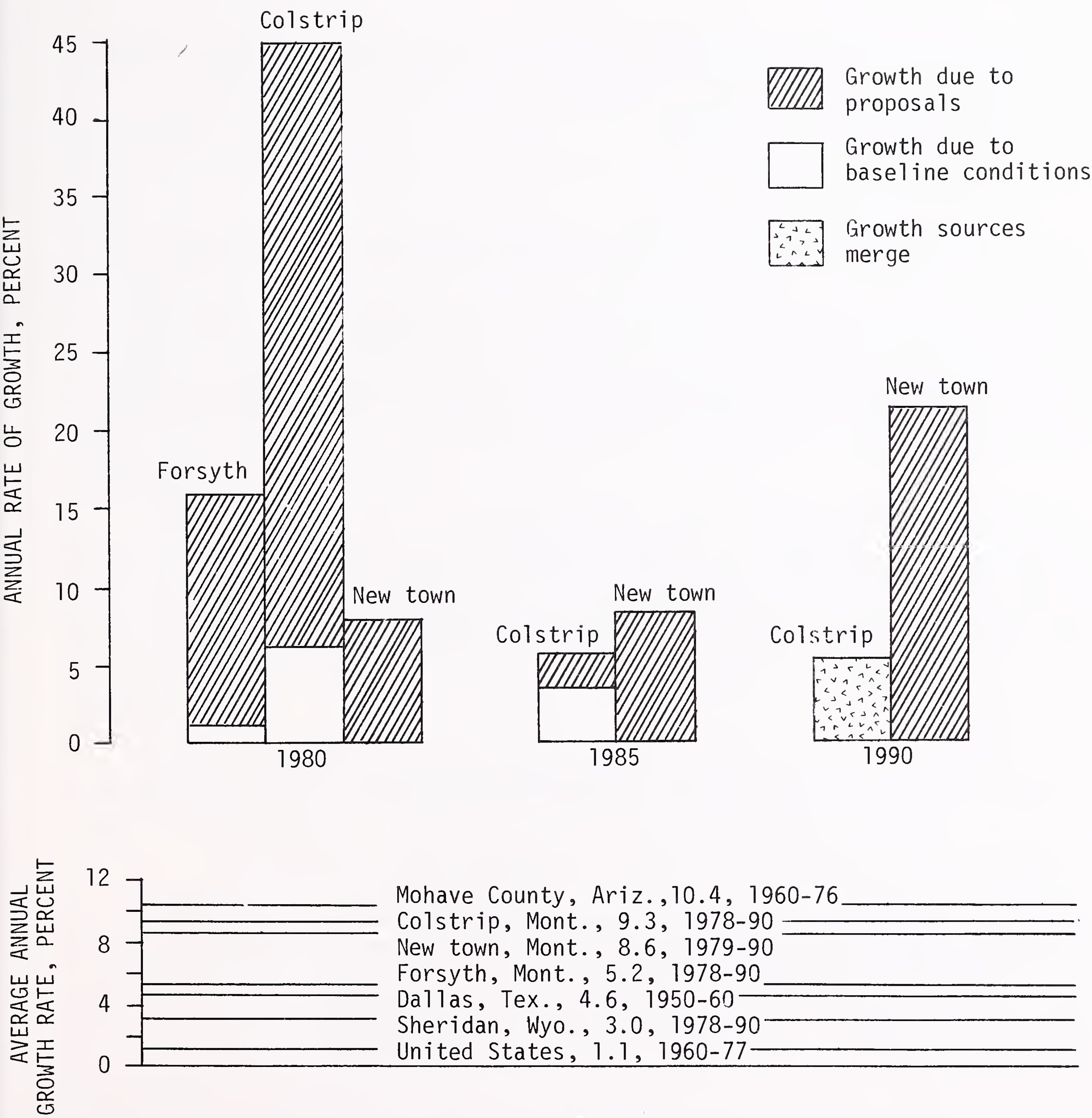


FIGURE IV-12.--Average rates of population growth in impacted towns. Bar graphs (top) show annual rates of growth in benchmark years; towns with less than 5 percent annual growth during these years are not shown. Horizontal lines (bottom) compare average growth rates in the same towns from 1978-90 with average growth rates in other areas.

Dallas, Texas during its industrial expansion (fig. IV-12). These rates of growth suggest that Colstrip, Forsyth, and the new town may grow too fast to allow for effective management. Sheridan would grow at a more manageable rate, but the town appears to lack a commitment to policies of growth management (EPA, 1977).

2. Social Environment

The most serious impacts of the proposed developments would be on ranchers, transient newcomers, school-age children, the poor, the elderly, and Native Americans. Some individuals in these groups would suffer from abusive behavior, mental illness, alcoholism, and crime due in large part to the rapid population increases in the towns listed above. They would also suffer from housing shortages, inflation, and resulting stress. The proposals would add incrementally to these problems, although they would exist to some degree with coal development projected in the absence of the proposals.

The values and lifestyles of this rural agricultural society would progressively be replaced by those of a more urban, industrial society--a continuation of a trend only a decade old in the rural parts of the region. These changes would likely occur even without the proposed developments; that is, projected concurrent development would probably be sufficient to continue this trend of cultural change.

a. Adverse effects on individuals

Ranchers and farmers in Rosebud and Big Horn Counties would continue to be displaced from positions of power and esteem by additional mining-induced newcomers. People in these counties have traditionally met many of their trade and service needs in the larger communities of Billings, Sheridan, and Miles City; thus, most of the merchants, industrialists, and government representatives whose ways of life could potentially conflict with those of the ranchers and farmers have been far removed from the rural areas. The anticipated population influx to Rosebud and Big Horn Counties would probably alter the situation by expanding the influence of merchant and industrial interests. For example, the industrial community of Colstrip would become the largest town in Rosebud County (replacing Forsyth), and the new town in Big Horn County would attract merchants to serve demands previously met in Sheridan County, Wyoming.

Ranchers might well lose the ability to influence water allocations and property tax levels. They might see long-time associates move out of the community or out of positions of authority. With this loss of power would also come a loss of deference and esteem. This loss could be translated into personal suffering as ranchers experienced stress and dissatisfaction from the displacement or reduction in perceived significance of roles, people, places, and cultural events having symbolic meaning to them. Ranchers could be expected to protest this loss (whether real or perceived) in a manner similar to ethnic groups in inner cities,

who join in mass action to protest transportation links or urban redevelopment projects.

New mining development projected to occur even without proposed developments would probably be sufficient to cause these changes in Rosebud and Big Horn Counties; the changes are to some extent already under way. The proposed mines and generating units would accelerate the existing trend. Ranchers and farmers in Sheridan County have already lost their political and social dominance, so the proposals would not change the existing cultural situation.

Although the communities would try to adjust to new needs for government and professional services, the ability to deliver these services would be strained. (See Community Services.) Public servants would not be able to pay as much attention to the informal and social aspects of their jobs. The loss of the more personal service and slow pace of life generally possible in small towns would lead to dissatisfaction and stress among many individuals.

These stresses and the dissatisfaction they cause may be translated into additional abusive behavior, mental illness, alcoholism, and crime, with consequent impacts on its victims. Others expected to be adversely affected include low-income people, the elderly, and the handicapped. As more people begin to enjoy higher than average wages, those with low or fixed incomes may not be able to compete for higher-cost housing or maintain adequate nutrition without further subsidies (Gold, 1975; HUD, 1976).

Social impacts on individuals would be fairly closely linked to population growth; the proposed developments would, therefore, more directly affect individuals than the society or culture as a whole.

b. Benefits to individuals

Some of the changes in the study area, such as shopping malls and other new businesses, might be perceived as benefits. Opportunities for entertainment would increase as would community-wide cultural programs through libraries, special fairs, or exhibits. The increased pace of life, seen as threatening to some, would be exciting to others.

As the impacted communities increase in size, economics of scale would lower the per-capita costs of some government services. This would reduce tax burdens and/or increase the quality of services. Increased personal and business incomes would allow greater purchasing power, and increasing employment opportunities might allow women and other minorities greater job and class mobility. Discrimination against minority groups would likely continue; however, the proposals would not add to this problem.

Some elderly may be able to sell their homes at high prices and improve their standard of living in rental or townhouse developments, or

by migrating out to lower-cost areas. This would mitigate to some extent the loss of conditions that made Sheridan (in particular) a desirable retirement community.

c. Problems in forecasting impacts

Social impacts would depend to some extent on the ability of local governments to plan for growth and provide social and physical services for an increasing population. There are indications that some communities, notably Sheridan, have had difficulty anticipating and meeting these needs. Our projections are necessarily based on the current situations and would not account for any great improvements in the ability or willingness of communities to plan for and manage coal-related growth.

It is not possible to foresee what effects the proposed developments would have on the basic social units of the study area (family, church, government, voluntary organizations, etc.). The analysis concentrates instead on anticipated individual gains and losses. Additional knowledge of social units in the study area would allow better predictions of impacts.

People in the study area may continue to experience stress caused by uncertainty about the future of industrial development. In past years, government and industry projections (for example, U.S. Bureau of Reclamation, 1971) of very rapid industrialization in the area have caused considerable anxiety among ranchers and farmers. Better projections of growth and analysis of its consequences may help allay fears of rapid, disruptive development on the part of ranchers and farmers in the study area.

I. ECONOMICS

1. Employment

The proposed mines and generating units would not substantially change the trend of increasing employment in the six-county study area (see fig. IV-13), nor would they substantially change the areas in which those increases are occurring. Total employment in the Montana portion of the study area would increase 45 percent from 1975 to 1990 with the proposed developments; the increase would be about 33 percent without them. The proposals would create about 1,800 new jobs, about 8 percent of the anticipated total of 23,000 jobs in 1990. Table IV-9 shows projected employment distributed by cause in the study area.

Most of the mining-related increases would be in Big Horn County (an 89 percent increase in total employment) and Rosebud County (a 71-percent increase). Total employment in Sheridan County would increase 61 percent. These increases would begin to occur in 1979. Big Horn County would grow more than Sheridan County due to the siting of a new town in southern Big Horn County, near Decker, which would shift some of the anticipated employment growth away from Sheridan. By 1990, 60 percent of the jobs in Big Horn County would be derived from coal mining. Sheridan County

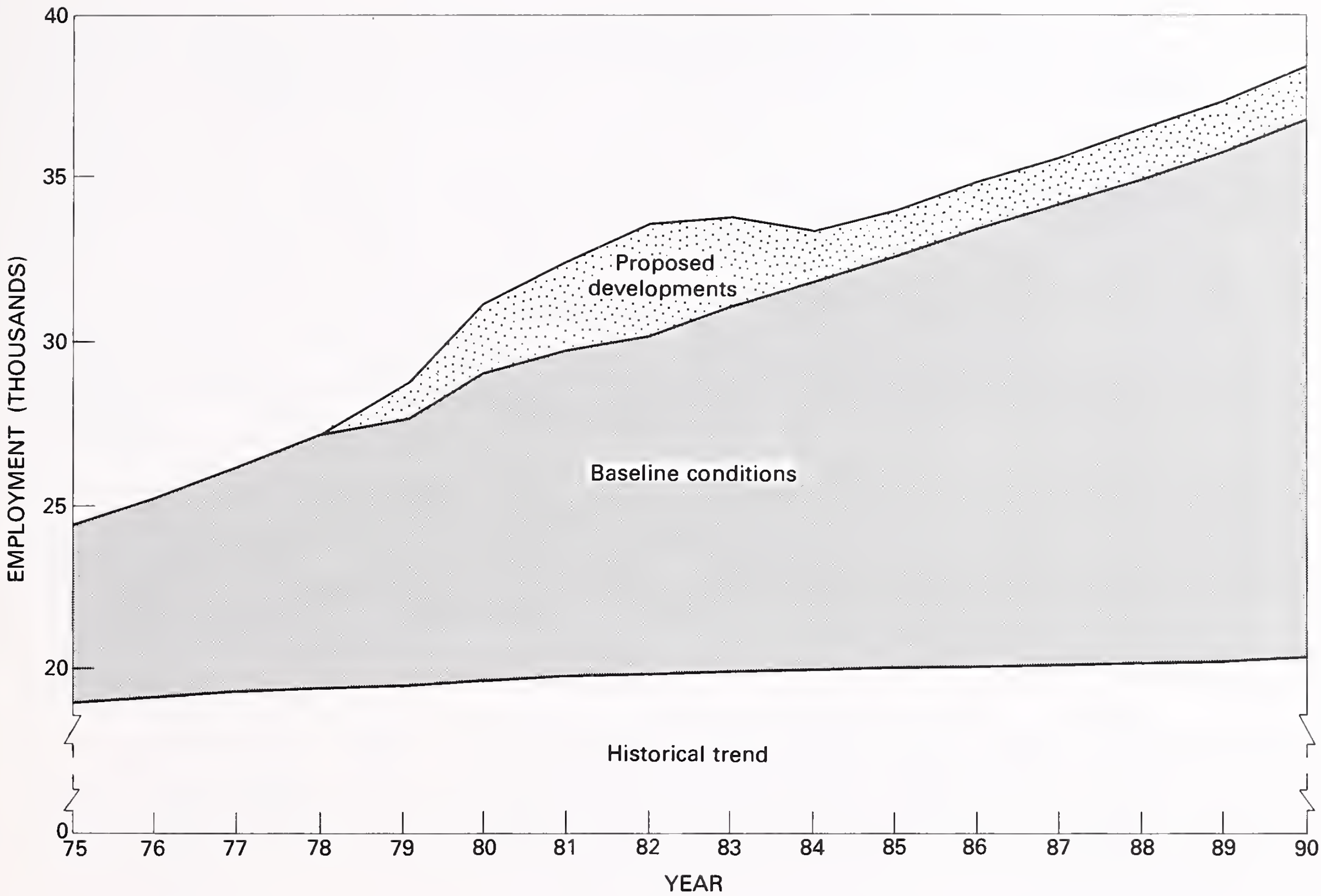


FIGURE IV-13.--Total employment attributable to various causes in the six-county study area.

would grow essentially as fast with or without the proposed mines. The new town would absorb most of the increases that would have gone to Sheridan. (See table IV-9.)

Total employment for Custer County would probably increase at the same rate as statewide employment, due primarily to the growth of Miles City, and Powder River and Treasure Counties would continue to grow slowly. The proposed developments would have little or no effect on these counties.

Most of the new employees for the proposed developments would come from outside the area for several reasons: the local supply of trained labor is essentially exhausted (Martin White, oral commun., 1978); the hiring halls for the main mining union are located in Helena and in Casper; and over one-half the worker-years would be in short-term construction.

An important short-run source of employees for the ancillary sector would be spouses and older children of the induced in-migrants, since

TABLE IV-9.--Total employment, attributable to various causes

	1980				1990			
	Historical trend[1]	Baseline	Proposed actions	Total employment	Historical trend[1]	Baseline	Proposed actions	Total employment
Big Horn County:								
Number	3,093	2,152	869	6,114	3,097	3,682	950	7,729
Percent	51	35	14	100	40	48	12	100
Custer County:								
Number	5,448	0	0	5,448	6,316	0	0	6,316
Percent	100	0	0	100	100	0	0	100
Powder River County:								
Number	955	15	0	1,285[2]	912	15	0	1,322[2]
Percent	74	1	0	100	69	1	0	100
Rosebud County:								
Number	2,283	2,440	1,394	6,117	2,569	3,954	871	7,394
Percent	37	40	23	100	35	53	12	100
Treasure County:								
Number	398	100	0	498	448	50	0	498
Percent	80	20	0	100	90	10	0	100
Montana study area:								
Number	12,177	4,707	2,263	19,462	13,342	7,701	1,821	23,259
Percent	63	24	12	100	57	33	8	100
Sheridan County, Wyo.:								
Number	7,335	4,438	-20	11,753	6,875	8,263	-149	14,989
Percent	62	38	0	100	46	55	-1	100
Study area total:								
Number	19,512	9,145	2,243	31,215	20,217	15,964	1,672	38,248
Percent	63	29	7	100	53	42	4	100

[1]McQuiston (1978), all other figures are from Coal Town II, 1978.
[2]Total employment includes increases associated with petroleum development.

they would have time available and would not demand as high pay. Because the mining sector would receive higher than average pay, some farm laborers--traditionally a low income group--could possibly also receive higher wages as a side benefit from the increase in mining employment. Employment would probably increase least among the poor--primarily the elderly, children, Indians, female heads of households, and the "underemployed."

The construction and operation of Colstrip units 3 and 4 would tend to concentrate the employment effect in the town of Colstrip. If the units are built at Colstrip, the approximately 340 long-term railroad jobs that would otherwise be needed to ship the coal to a load center would not be created.

Of the 9,100 man-years directly associated with the generating units from 1979 to 1990, about three-fourths would be in short term construction and one-fourth in long term operation and maintenance. Employment would peak at over 2,000 workers during the fourth year of construction. There would be about 250 long term jobs associated with the operation of the units.

Most of the capital goods used by the proposed strip mines and generating units would be manufactured outside the area; thus, the majority of benefits associated with additional employment, income, profit, and investment in these secondary industries would also occur outside the area. Perhaps 1 to 2 jobs in manufacturing would be required for every new mining-related job in the study area. The economic impacts outside of the area could well be greater than within; however, the relative impact would likely be greatest within the area because the population there is smaller than in the manufacturing and distribution centers.

This "export" of jobs in manufacturing and trade is a feature of any extractive industry whose processing facilities and financial institutions are located some distance from the point of extraction. The economy of Montana is heavily based on extractive industries and does not have a corresponding financial center or manufacturing sector. The proposed developments would do little to change this situation.

2. Income

The proposed actions would add to total personal income in the six-county study area. At 1978 wage rates, (table II-26) total annual personal income would increase by about \$24 million: \$15.8 million in the basic sector and \$8.2 million in the ancillary sector. This is a long run effect which does not include income from temporary construction jobs. The additional annual income from the proposed developments would be about 7 percent of total income projected under baseline conditions.

3. Expenses and Revenues for Local Governments

The Coal Town II model (Temple, 1978) was used to project future revenue and expenditure trends for local governments in the area. Tables IV-10, IV-11, and IV-12 show the relationship between revenue and spending estimates each year through 1990. If revenues increase faster than expenditures, the ability of governments to finance local services will be greater than if expenditures rise faster than revenues.

TABLE IV-10.--Annual growth rates of revenues and spending, Big Horn County, Montana

[Data are in percent. Source: Coal Town II, 1978]

Year	County		School district	
	Revenue	Spending	Revenue	Spending
1978---	17.9	0.5	3.8	0.8
1979---	35.4	9.7	20.8	15.1
1980---	-18.0	4.7	8.2	7.3
1981---	23.9	.1	9.0	.2
1982---	21.4	.2	9.2	.2
1983---	5.1	.8	3.1	1.2
1984---	7.5	1.7	5.0	2.6
1985---	2.9	1.2	2.4	2.6
1986---	-.2	1.4	1.0	2.1
1987---	-.2	1.4	1.0	2.1
1988---	-.1	1.4	1.1	2.2
1989---	-.1	1.5	1.1	2.3
1990---	-21.0	4.0	3.4	4.0

The proposed mines would not markedly change revenue and spending trends for local governments in the study area. For Big Horn County and its school districts, the ability to raise revenues would generally increase faster than the need to raise revenues (table IV-10). For Rosebud and Sheridan Counties and their school districts, expenditure estimates would generally increase faster than revenue estimates (tables IV-11 and IV-12). The proposed developments would not affect expenses and revenues in Powder River, Treasure, and Custer Counties. Revenues in Treasure County will increase considerably from projected coal production on the Crow Ceded Strip beginning in 1981. Increases in expenditures will remain constant because most of the new workers will live in Big Horn County. Other than the projected coal production, very little growth is expected in Treasure County. In Powder River County and its school districts, expenditures will generally increase faster than revenues, due mostly to declining oil and gas production in the Bell Creek field.

TABLE IV-11.--Annual growth rates of revenues and spending Sheridan County, Wyoming

[Data are in percent. Source: Coal Town II model]

Year	County Revenue	County Spending	School district Revenue	School district Spending
1978---	-3.1	2.2	1.8	2.3
1979---	10.9	.2	4.1	.2
1980---	20.3	3.3	10.1	3.5
1981---	-2.8	1.1	1.0	1.1
1982---	1.8	1.7	1.6	1.8
1983---	1.4	2.1	2.0	2.3
1984---	.2	1.7	1.6	1.8
1985---	1.5	1.9	1.8	2.0
1986---	1.2	2.1	2.0	2.3
1987---	1.2	2.2	2.1	2.3
1988---	1.3	2.2	2.1	2.3
1989---	1.3	2.2	2.1	2.4
1990---	11.4	6.0	8.8	6.4

TABLE IV-12.--Annual growth rates of revenues and spending, Rosebud County, Montana

[Data are in percent. Source: Coal Town II model]

Year	County Revenue	County Spending	School district Revenue	School district Spending
1978---	-19.0	0.7	-8.7	1.0
1979---	5.1	3.1	4.6	4.7
1980---	-12.3	11.8	17.3	18.6
1981---	-2.0	7.5	8.2	11.7
1982---	.9	5.0	6.2	7.8
1983---	33.9	-.7	7.1	1.1
1984---	22.3	-1.4	5.0	2.1
1985---	-1.7	.2	-.3	.4
1986---	.1	1.3	1.4	2.0
1987---	-1.5	1.3	.9	2.1
1988---	7.5	1.4	3.8	2.2
1989---	1.0	1.4	1.8	2.2
1990---	.7	4.0	4.4	6.2

Estimated per-capita town revenue (constant dollars) would generally decline in each county. Revenues to the State of Montana would increase substantially from the additional taxes from the proposed mines. (See table IV-13.)

TABLE IV-13.--Projected revenues, Montana (1970 dollars)

[Source: Property taxes, unemployment insurance, corporate license tax, miscellaneous fees, alcohol tax, motor vehicle and gasoline tax, cigarette tax, personal income tax, and electrical production tax]

	Levels of Coal Production			
Year	Baseline	Intermediate	Low	High
1978---	$45,925,000	$47,525,000	$45,921,000	$47,525,000
1979---	53,626,000	57,276,000	50,889,000	57,412,000
1980---	58,152,000	66,786,000	45,466,000	66,902,000
1981---	65,870,000	79,311,000	57,076,000	84,181,000
1982---	76,567,000	94,800,000	59,235,000	99,218,000
1983---	79,899,000	102,590,000	60,632,000	110,521,000
1984---	86,613,000	110,659,000	64,603,000	122,141,000
1985---	87,902,000	111,581,000	70,940,000	131,286,000
1986---	88,220,000	111,926,000	74,684,000	141,502,000
1987---	87,140,000	110,864,000	74,804,000	141,852,000
1988---	91,917,000	112,993,000	74,923,000	152,787,000
1989---	92,647,000	116,414,000	75,050,000	157,176,000
1990---	92,957,000	116,736,000	75,239,000	162,288,000

The new town in southern Big Horn County would ease Wyoming's fiscal strain. Some of the new town's residents would move there from Sheridan; most would be newcomers who would locate in the new town instead of in Sheridan. Most of their public service needs accordingly would be in Montana instead of in Wyoming. Increased coal production in Big Horn County would increase property tax revenues, which should provide the necessary county revenues for the new town's residents. Assuming that there would be mines in the school districts associated with the new town, they would be able to raise funds for new facilities.

The construction of Colstrip units 3 and 4 may cause sporadic economic growth creating major problems for local government financing in Rosebud County. Construction of the units would probably cause county expenses to increase faster than taxable value for several years. Expenses for community services would increase abruptly with the arrival of construction workers, but revenues would increase several years later, when a significant amount

of property taxes could be levied on the completed generating units. This happened when units 1 and 2 were built. In the early years of the units' construction, the cost of public services in Rosebud County grew faster than taxable value. This is indicated by a substantial rise in mill levies for county government purposes--from 36.14 in 1966 to 54.55 in 1971. By 1975, considerable new property had appeared on the tax rolls, and the gross valuation of coal increased, causing mill levies to drop to 24.05. By then, the boom construction period was over, and workers were leaving the area.

Considering the relatively short life expectancy of the units, the local economy is likely to experience another bust after 30 or 40 years of operation. Such a bust would cause economic hardships for local citizens.

4. Trade

The major effect on business patterns from the proposals would be from the new town near Decker, which would draw some business from Hardin and Sheridan. As a result, Hardin would grow only 70 percent as much as it would without the proposed developments. Growth in Sheridan retail trade would be slightly less than under baseline conditions because of competition from the new town and from the intervening communities of Ranchester and Dayton. Greater growth in wholesale trade in Sheridan from the proposals would offset the lesser growth in retail trade. Colstrip could become the dominant trade center in Rosebud County, replacing Forsyth, largely due to construction and operation of Colstrip units 3 and 4.

Banks in the study area would be able to finance less than 40 percent of needed capital. Interest earned on the one-half of agricultural capital now provided by out-of-state sources, along with all interest earned on loans to large mining companies, accrues to those out-of-State entities, thus leaving Montana. A large part of retail sales also leaves the state, with the combined result that much of the money spent by Montanans does not create additional jobs and earnings within the state. The export of capital also reduces the investment in job-producing activities. This effect is worsened when, as is apparently the case, raw agricultural and mineral products are sold out-of-state at less than their replacement (including social) cost.

5. Externalities

More than 60 percent of the available electricity and economic benefits from the use of electricity from units 3 and 4 would be exported from Montana (Montana Department of Natural Resources and Conservation, 1974). Load generation (rail transport of coal) does a better job of exporting externalities than minesite generation (transmission lines); therefore, the construction of units 3 and 4 will most likely create additional negative impacts at the generation site and along the right-of-way of the power lines than would occur through shipments of coal to out-of-State facilities having similar generating capacity.

Some of the external costs to the Colstrip area due to the generating units (air pollution, degradation of water quality, disruption of wildlife populations, and damage to vegetative growth) could be passed on to some local ranchers in the form of slightly decreased agricultural productivity. These environmental impacts are discussed in more detail in their respective sections. External costs in the Decker area would be similar, except that no generating units would be built. Air-quality impacts would be less widespread, and there would not be a major surge of new construction workers.

If coal producers do not pay all their costs, including external costs, there may be a tendency to over-develop coal resources in the area, resulting in a social welfare loss.

6. Reservation Economics

The proposed developments would not appreciably change trade and capital-flow patterns on the Crow and Northern Cheyenne Indian Reservations because the strong cultural traditions of the tribes will tend to inhibit changes in those patterns. The proposals also would not appreciably change employment and income on the reservations because most of the new mine employees would be non-Indian and would not live on the reservations. A small number of Northern Cheyenne would probably work on the construction of Colstrip units 3 and 4.

J. COMMUNITY SERVICES

The need to construct facilities, hire personnel, and plan for impacts would be greatest in Colstrip. That community, however, appears to be able to adequately anticipate and provide for most of these needs. Forsyth would not have as great a need for additional community services, but its ability to meet those needs is less certain, and thus the most serious impacts on community services would occur there. The proposed developments (primarily Colstrip generating units 3 and 4 and to a much lesser extent the Big Sky mine expansion) would account for much of the anticipated population growth in these communities; hence, for much of the impact on community services.

Mental health services, including drug and alcohol counseling and treatment, crisis intervention, family counseling, and institutional screening, would be the most severely impacted type of service in the study area. Because growth in Colstrip and Forsyth would be rapid and temporary, these communities would find it difficult to adequately meet the needs of the new population without overbuilding and overstaffing for the long term.

Big Horn County would not suffer the same magnitude of impacts as Rosebud or Sheridan Counties because growth would not be as rapid in Big Horn County. The adequacy of community services in the new town cannot be accurately predicted in the absence of detailed plans. Sheridan County

would provide many services to residents of Big Horn County as well as to its own residents; impacts would thus be more severe than in Big Horn County, but somewhat less severe than in Rosebud County. Sheridan County, being more populous than the other counties of the study area, has an infrastructure more able to absorb additional growth; however, the county has not yet shown a great willingness to manage growth-related impacts. The proposed Pearl and Spring Creek mines would contribute about one-fifth of the growth in these counties.

Tables IV-14, IV-15, and IV-16 summarize anticipated impacts on community services. Services provided in or by communities and counties in the study area include.

. Public works--including roads; sewer and water systems; garbage collection and related activities; public housing in all cases and private housing in those cases where it is constrained by availability of roads, sewer or water connections, and capacity.

. Education--schools, their staff, and supporting services.

. Security services--law enforcement, fire, and disaster relief provided by counties and communities.

. Social and health service--Federal, State, local, and private welfare agencies and their staff and facilities; public health including hospitals, private practioners (doctors, dentists), public health nurses, and in-community programs (e.g. homemaker and nutrition services); mental health, drug, and alcohol programs and agencies.

In the future, some facilities and services which are not now adequate will become adequate through additions that are already planned. Thus the analysis, while covering all the above categories, concentrates on those service and facilities which will either not be adequate in light of the forecasted growth or will be severely strained by growth. These are presented by community in tables IV-14, IV-15, and IV-16. Each community appears as a column and each category of service is a row. In the box formed by the intersection of a row and column is a description of the type of impact.

Some general comments apply to all impacted counties. McQuiston (1979) found that an absence of necessary knowledge might lead to insufficient planning and "without planning, the impact, positive or negative, must and will be more important to each of these communities than should be the case." McQuiston concluded "positive impacts will be less completely realized as opportunities will pass because of the lack of planning and negative impacts will be more devastating than normal." The reader is, therefore, advised to view with caution the statistical information on numbers of personnel or increase in capacity of facilities set forth in table IV-14, IV-15, and table IV-16. It is very possible that, through lack of planning, several counties and communities will not make the adjustments shown in the tables in time (and, possibly, they may not make them at all).

TABLE IV-14.--Projected impacts on community services in Big Horn County, 1978-90

	Big Horn County	Hardin	Decker
		Public works	
Narrative	Housing shortages may develop leading to sanitation problems from squatters especially in the Spring Creek area. Wyola may have to develop sewer and water systems in place of wells or septic tanks.	Expansion of the water system would be necessary. If the planned improvements to the sewage system are completed, sewage capacity would be adequate.	No community facilities are provided.
Statistics	Mobile homes increase to 152 percent of their current numbers.		
		Security services	
Narrative	No unusual problems other than normal increase in crime that comes with growth.	Law enforcement is provided by county.	County has responsibility for security services.
Statistics	Sheriff would need 5 to 7 more deputies and 1 to 2 more patrol vehicles. Fire crews would need 1 more truck.	Five additional volunteer firemen and 1 additional fire truck would be needed.	
		Education	
Narrative	See individual communities.	No unusual problems are forecast other than those which normally come with growth.	New town of Spring Creek would need 8 classrooms and 9-11 teachers.
Statistics		22-26 classrooms and 26-30 teachers would be needed.	
		Social and health	
Narrative and Statistics	Social welfare, although a State and Federal responsibility, is provided in Hardin (primary care) or Billings (specialist). A similar situation exists in health.	Ten to 12 hospital beds and 4 to 5 physicians would be needed. Eight additional caseworkers needed.	See Hardin, as public health and welfare is centralized there.

TABLE IV-15.--Projected impacts on community services in Sheridan County, 1978-90

	Sheridan County[1]	Sheridan	Dayton/Ranchester
		Public works	
Narrative	Housing shortages are likely due to volume of dwellings needed (see statistics) and/or bottlenecks in subdivision/mobile-home park approval process. Story and Big Horn may have to eliminate wells and septic tanks and develop community water and sewer systems	Most growth would occur here (65-75 percent of all Big Horn Co. miners would locate in Sheridan). The planned additions to sewer and water central facilities should be adequate.	The current (1978) water and sewer systems are inadequate. Both communities would need new central plant as population would more than double.
Statistics	See individual communities	A 49-percent increase in number of dwellings would result in a need for 3,600-3,700 additional sewer and water connections.	The future number of dwelling units in Dayton would be 218 percent of current levels while Ranchester would have 285 percent of current levels (1,200-1,500 dwellings each)
		Security services	
Narrative	Centralization of deputies in Sheridan would lead to difficulty in dealing with increasing vandalism in rural communities.	No significant problems are predicted other than what would normally come with growth.	Police protection would be provided by the county.
Statistics	Three to four additional deputies and one additional cruiser would be needed.	Two new fire stations (north and south) would be needed with two trucks each and at least 24 firemen (12 per station); 14-16 officers and three to five vehicles would need to be added to the force	Volunteer fire districts should have adequate personnel and equipment.
		Education	
Narrative	Sheridan County is attempting to discourage mobile home parks and should get more of the stable employees who desire permanent housing. Therefore, student turnover should not be a problem.		
Statistics		School District II would need 85-90 classrooms and about 100 additional teachers.	School District I would need 15-18 new classrooms and about 20 additional teachers.
		Social and health	
Narrative and statistics	The increasing personal incomes should shift welfare needs from maintenance (AFDC, food stamps) to intervention type activities. Counseling for and prevention of drug, alcohol and wife/child abuse problems will be critical.	Mental health - at least one family counselor, two generalist psychologists and one alcohol/drug counselor would need to be added. Hospital private medical sector - 25-40 additional beds and 15-18 physicians should be added. Social services - at least 6 additional caseworkers would be needed.	Health and welfare services will remain centralized in (the city of) Sheridan.

[1]Includes County-served unincorporated communities.

TABLE IV-16.--Projected impacts on community services in Rosebud County, 1978-90

	Rosebud County[1]	Forsyth	Colstrip	Lame Deer
		Public works		
Narrative	All sewer and water systems would need expansion. Subdivision/mobile home park applications would double or triple in rate on an annual basis. Ingomar and Birney may need community water and sewer systems in place of their existing wells and septic tank/drain fields.	The solid waste landfill closed at Forsyth in favor of a multicommunity-coop venture may have to reopen as the cooperative venture would become inadequate.	Water system may not be adequate to provide volume and pressure needed for fire suppression.	The entire water system, including intake and treatment facilities, may have to be replaced to provide enough capacity.
Statistics		Water and sewer systems connections would increase 80-90 percent (775-825 new dwellings).	Number of dwellings would nearly triple from about 660 to 1,750-1,850.	
		Security services		
Narrative	County fire protection should be adequate given planned additions.	See county on law enforcement.[1]	See county on law enforcement.[1]	The question of jurisdiction of tribal police (Northern Cheyenne) over "white" crime may "heat up" with potential for conflict.
Statistics	The county sheriff[1] would need 12-14 more deputies and three to five additional cruisers. Ashland would need 14-16 more volunteer firemen and one truck.	Five to seven additional full time and 12-15 volunteer firemen would be needed along with two additional fire fighting vehicles.	21 additional volunteer firemen and three fire trucks needed at peak of construction of units 3 and 4.	No unusual needs forecast. Police personnel should be adequate.
		Education		
Narrative	Turnover of children in classes very high for 2-4 years during peak of construction. Teacher satisfaction reduced, completion of lesson plans difficult, discipline a problem.	Normal problems that accompany growth.	Greatest turnover of students occurs here. Recruiting and retention of teachers may be a problem.	Greatest conflict between white and minority and old and new student factions. Recruiting and retention of teachers a problem.
Statistics	Rosebud needs four to six additional classrooms and six to eight teachers at height of construction, of which 50 percent must be soft.[5]	18 new teachers and six additional classrooms may be needed.[2]	30-35 additional classrooms and 26 additional teachers would be needed, of which 20-30 percent must be soft.[3,5]	26-30 new classrooms and 20 added teachers would be required, of which 40 to 50 percent must be soft.[3,5]
		Social and health		
Narrative	Heavy impacts on protective services, family counseling and drug/alcohol programs.	Unable to identify any unusual types of problems not present in the larger society.	See Forsyth	Some Northern Cheyenne health, drug abuse and alcohol treatment would be handled through (U.S.) Public Health Service at Crow Agency.
Statistics		20-25 hospital beds[4] and four to five additional physicians needed. Two county-wide caseworkers need to be added.	A clinic with five to seven physicians and supporting staff needed. Satellite social services office with one caseworker would be needed.	No significant problems forecast.

[1]Law enforcement in all non-Indian areas (including towns and cities) is the responsibility of the sheriff.

[2]McQuiston (1979) found a great deal of spare capacity in Forsyth schools in terms of available space.

[3]McQuiston (1979) found spare capacity in Colstrip and Lame Deer in terms of student-teacher ratios. Colstrip could absorb 150-200 more students and Lame Deer could add about 85-100 and still have "good" student-teacher ratios (18/1).

[4]The Forsyth hospital is a "joint" facility covering all of Rosebud County with participation by Treasure County.

[5]A "soft" development must be short term and disposable as the population it will serve is temporary.

K. LAND OWNERSHIP AND USE

Impacts on land use would be relatively minor: the land uses temporarily displaced by the proposed mines and Colstrip units 3 and 4 are abundantly available on other lands throughout the study area. Subsurface ownership would probably not change, but surface ownership of the minesites would probably ultimately revert to ranching interests, although that is not specified in any of the mine plans.

Existing, proposed, and projected mines and Colstrip units 3 and 4 would disturb about 23,000 acres between 1978 and 1990. (See fig. IV-14.) About 9,000 of these acres would be reclaimed by 1990; most of the remainder would be reclaimed after 1990. Land use on about 2 percent of the 23,000 acres would be essentially permanently changed: about 400 acres by residential uses, and 40 acres by Colstrip units 3 and 4.

During mine life, land use for coal mining would preclude grazing on the three proposed minesites and curtail land use as watershed and wildlife habitat. About 140 million tons of coal would be removed by 1990 and about 7,400 acres would be disturbed by the proposed mines and all ancillary facilities, including rights-of-way for transportation and utilities (fig. IV-14 and tables IV-17 and IV-18). This acreage would represent about 0.15 percent of the total designated region. Mine-related developments would displace other land uses through 1990, and beyond. Even if the three proposed mines were to trigger considerable additional mining, changes in land use would generally be temporary (typically about 20 years) and relatively minor, especially after mining. (Compare chapter VIII, high level.) The changes would, however, be strongly felt, especially by long-term residents. (See Sociology, chapter IV.) The most significant impact would be due to regional population increases induced by the proposed developments. From a regional perspective, the increased population would require an insignificant amount of additional land for residential and commercial developments.

Roads due to mining, and generally improved access within the region, would reduce its remoteness and cause increased trespass, with associated increases in vandalism, litter, and fire hazard. New roads, rail lines, and utility rights-of-way would use about 700 acres (table IV-18), and new telephone lines and the relocation of local-service electric lines would use additional land. The increase in rail traffic would also decrease the usefulness of a wider zone of land along the rail corridor. (See Transportation, chapter IV.) Lands used for transportation corridors would displace other uses possibly for a decade or two after mining. Some of these land commitments would last longer than the mines they would serve. It is anticipated that about one-fourth of the lands probably to be mined in the designated and adjacent areas by 1990 would be returned to essentially premining uses. (See Vegetation, chapter IV.) It is not yet known to what extent mined lands would need more careful management than before mining in order to sustain the level of livestock grazing and wildlife habitat that they now support.

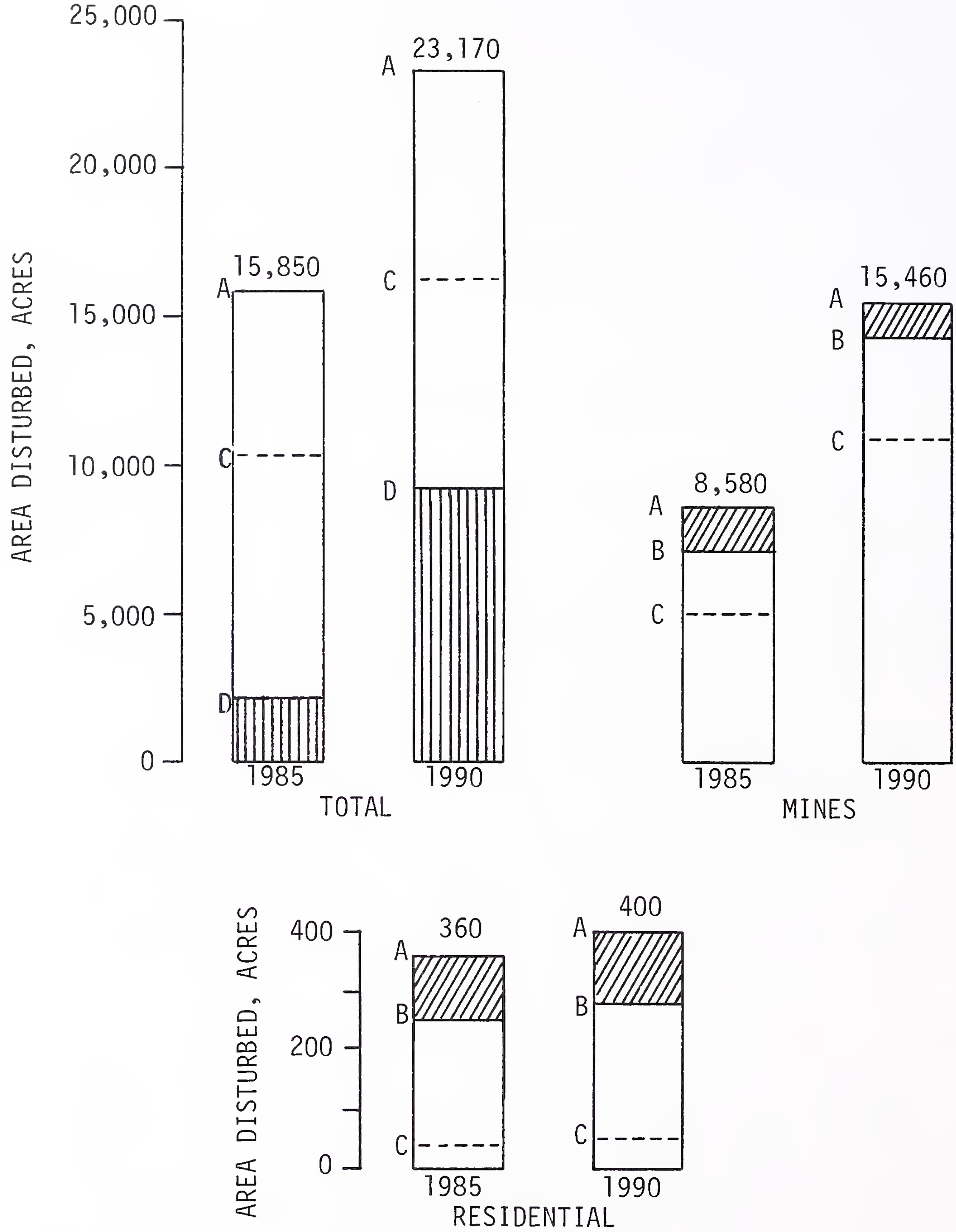


FIGURE IV-14.--(A) Cumulative area disturbed by mining and derivative activities since 1978. Diagonal rules show disturbance due to proposed developments. Vertical rules (D) show area reclaimed since 1978. Base of diagonal rules (B) shows area disturbed under baseline production level. Dashed line (C) shows area disturbed under low production level. (See chapter VIII.)

TABLE IV-17.--Land requirements for proposed mines by 1990[1]

	Mine pits (acres)[2]	Facilities[3]	Associated disturbance[3,4]	Total (acres)
Peabody Big Sky-------	1,024	28	343	1,264
Spring Creek----------	756	699	1,866	3,321
Shell Pearl-----------	339	185	1,457	1,981
Total---------------	2,119	912	3,666	6,697

[1]Projected beyond the first 5-year permit period for each mine.
[2]Based on proposed production tonnages and seam thickness.
[3]Based on acreage to be bonded.
[4]Includes topsoil and overburden storage areas; overlaps mine pits and facilities over mine life.

TABLE IV-18.--Land requirements for transportation and utilities associated with proposed mines

	Miles	Acres	Width of right-of-way (feet)
Powerline right-of-way----------	19.6	138	60
Rail line extensions------------	21.0	*509	200
Mine access and county road relocation--------------------	5.3	65	100
Totals----------------------	44.9	712	

*Includes 191 acres in Sheridan County, Wyo.

During mine life, the minesites could not be used for livestock grazing. About 8,650 AUM's of forage production would be lost through 1990 as a result of the three proposed mines. Assuming that one AUM on privately-owned surface is currently worth 5 to 10 dollars, these lost AUM's would represent roughly $43,000 to $86,000 of unrealized production. About 6 years after abandonment, the minesites could again be used for grazing, although they would probably support somewhat fewer cattle than at the present level. Transportation corridors would have some impacts on grazing, less because of the amount of land they would use (table IV-17) than because of the barriers they would impose to animal movements.

Impacts on farming would be neglible. Only the Spring Creek minesite includes lands suitable for even marginal farming (Soils, chapter II); it currently includes a few acres that have been used as dry cropland.

The proposed mines would not directly impact any prime farmland. Prime farmlands throughout the region have not yet been inventoried, but the only lands to meet the definition apparently would be those underlain by deep alluvial deposits with dependable irrigation water, such as those along the Yellowstone River and several tributary streams. Towns and transportation facilities would continue to expand preferentially onto the best agricultural lands on level sites and irrigable stream bottoms. Abandoned commercial or residential developments would not legally have to be removed or reclaimed. It is estimated that about 1,400 acres of agricultural land would be used for new housing (400 acres) and secondary land use demand (1,000 acres) such as industrial, commercial, and public service as a result of the proposed developments. This represents only a fraction of one percent of the croplands in Rosebud, Big Horn, and Sheridan Counties.

Impacts on urban land use would be most severe in Colstrip, Forsyth, Hardin, and the new town, Montana, and Sheridan, Wyoming. All these towns are expected to be able to accommodate those changes. The new town of Spring Creek would semipermanently change some 360 acres of land from its present use and serve any unmet local residential need, as well as the proposed new mines (Cal Cumin, Project Director for Spring Creek new town, oral commun., June 20, 1978). A temporary construction camp along the Tongue River just south of Decker is proposed by the Spring Creek Coal Company to house Spring Creek mine construction workers; the camp would cover 16 acres and serve residents for about 2 years.

Impacts resulting from the three proposed mines on land use on the Indian reservations would be minor, induced by the overall growth in regional population and economic activity. The Pearl and Spring Creek mines would very slightly increase the demand for residential and commercial land in the south-central part of the Crow Reservation, perhaps in Wyola or Lodge Grass. The Big Sky mine expansion might very slightly increase such demand in Lame Deer.

The Northern Cheyenne Indian Reservation contains very little fee land which outside interests could develop without the full support of the Northern Cheyenne Indian Tribe. The more extensive fee and non-Indian land ownership pattern on the Crow Reservation makes the prospect of land use conversions which are not sanctioned by the tribe much more likely.

Use of the minesites as wildlife habitat would be greatly curtailed during mining, and slightly to moderately curtailed after abandonment. (See Wildlife, chapter IV.) Wildlife displaced to lands around the minesites would temporarily reduce the carrying capacity of those lands; this would be especially true for antelope displaced westward and southwestward from the Spring Creek and North Decker mines and from the new town. Transportation corridors, especially to the Pearl and Spring Creek mines would slightly curtail land use by big-game animals.

Use of the minesites as watershed would be negligibly curtailed either during or after mining. Effects on water quantity and quality would probably be minor and local. (See Hydrology, chapter IV.)

L. TRANSPORTATION

Impacts on the transportation system of the six-county study area would not be significant if currently-projected improvements to the rail and highway systems are made. The rail traffic increase attributable to these mines would be about seven train movements/day over several possible routes. The impact may be significant to those communities through which rail traffic already moves without adequate grade separations or buffering distance between the communities and the rail corridors. It should also be noted that rail traffic increases, although minor, would be experienced over routes of about 800 miles (upper Midwest) to 1,500 miles (Houston, Texas) in length. The indirect effects of coal train traffic on land uses along the rail corridors would be of moderate significance. (See Wildlife, chapter IV, and Social Environment, chapter IV.)

1. Highways

The most serious effect of the proposed developments on highway use would be from coal trains. The coal trains would block grade crossings, causing traffic delays and increasing the potential for train-vehicle collisions. New coal trains from the Spring Creek and Pearl mines would add as much as 25 percent to the already heavy and increasing railroad traffic as far east as Gillette, Wyoming. They would contribute accordingly to delays along the rail lines. The additional coal hauled from the expanded Big Sky mine would add to highway traffic at grade crossings along the entire shipping route east through North Dakota to Cohasset, Minnesota.

Grade crossings would be blocked 6 to 12 minutes by unit trains moving slowly (10-5 mph respectively) through towns, 2 to 3 minutes by faster moving trains, in rural areas. These figures do not include motorist delay before and after the train passes the crossing. Blockages of streets and highways by unit trains would add to the cost of public and private travel, mail service, and other tightly scheduled travel. Fire and ambulance service could be seriously delayed on occasion. Heavy rail use would in effect split some communities, erecting a physical barrier--which commonly results also in a social barrier--between residents.

The increase in train traffic due to the proposed mines would slightly increase the frequency of vehicle-train collisions over the current regional average of about 4 accidents per year, unless mitigated by additional grade separators or improved warning devices.

The proposed mines and generating units would increase highway use directly, due to workers and deliveries, and indirectly through population increases associated with the proposals. Projections of daily traffic are not available, but an estimated 6,100 new vehicles would be registered by 1990 in a five-county area (including Sheridan County) as a result of the population increase associated with the new mines. Increased traffic would be most noticeable on the incomplete section of I-90 between Sheridan and Crow Agency, on Route 315 from the Colstrip area to I-94, and on Wyoming Route 338 (Montana Route 314) from the Decker area to Sheridan. Some county roads

would receive increased use between the proposed mines and yet-undeveloped residential sites.

About 5.3 miles of State and county roads would have to be rebuilt or relocated in conjunction with development of the proposed mines. The necessary road work would cause delays and inconveniences; however, this would be a long-run improvement. The Montana Department of Highways plans the following improvements in routes that would be directly affected by proposed mining: four miles of resurfacing on FAS 314 north from the Wyoming line, and 23 miles of reconstruction of FAP 39 between Colstrip and I-90. Between 1983 and 1990, additional improvements are expected.

2. Railroads

Coal trains from the three proposed mines would not cause the projected capacities of any rail lines to be exceeded. They would account for perhaps 16 percent of all rail traffic leaving the designated region. The improvements needed to transport the projected baseline coal production would also be sufficient to handle production from the proposed mines through their life. Without Burlington Northern's projected improvements, however, coal traffic from the proposed, projected, and existing mines would approach, and possibly exceed the capacity of the main line between Nichols and Casselton, and would slightly exceed the capacity of the main line in eastern Wyoming.

A new 15-mile rail spur to the Pearl mine and a 9-mile spur to the Spring Creek mine would be built from the existing Decker branch line. The mileages include loading loops.

The proposed mines would account for seven of the 42 unit trains per day, including returning empty trains, needed to export 79 million tons of coal per year produced by 1990 (fig. IV-15).[2] Five of these trains, from the Pearl and Spring Creek mines, would account for about one-fifth of the 1990 traffic through Dutch Junction and on to Gillette. Some coal from the Spring Creek mine may be burned at the Jim Bridger plant in Wyoming. Two of the seven trains, from the Big Sky expansion, would use the Nichols-Colstrip branch and would add only about 8 percent to the traffic on the Burlington Northern main line to Cohasset, Minn. The present Big Sky mine accounts for about four percent of that traffic. Figure IV-16 shows the projected increase in rail use within the six-county study area due to the proposed mines.

3. Impacts of Transportation on Other Resources

a. Fuel use

About 57 million gallons of diesel fuel per year would be needed to ship the 13.2-mty production from the proposed mines to designated power

---

[2] An additional 9 million tons per year, produced from the Rosebud mine, would be burned at Colstrip generating units 1-4, and would therefore not be exported.

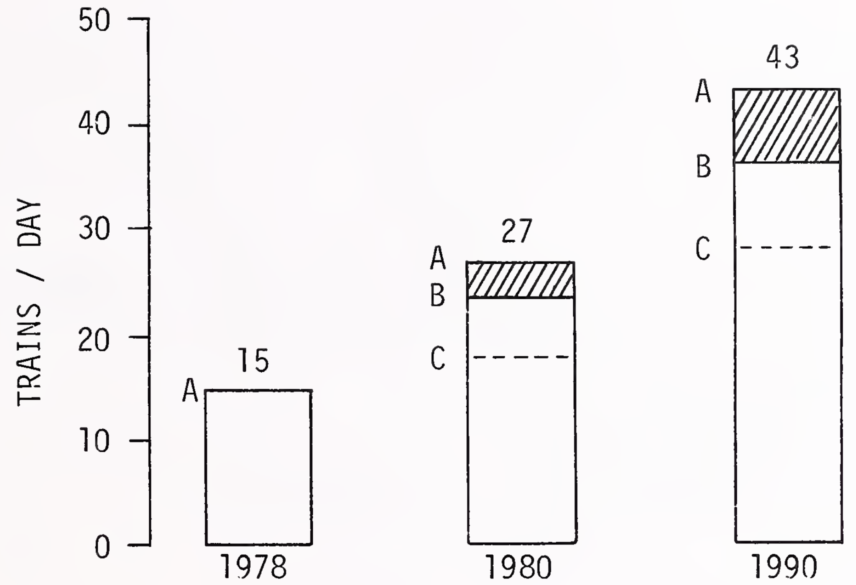


FIGURE IV-15.--(A) Projected number of coal trains per day from the study area to external markets (including returning empty trains). Diagonal rules show number of trains due to proposed mines. Base of rules (B) shows number of trains if the proposed developments were not approved (baseline production level). Dashed line (C) shows number of trains under low production level. (See chapter VIII.)

plants. This estimate is based on a net fuel efficiency of 300 ton-miles per gallon, and assumes shipping distances of about 800 to 1,500 miles. This would also represent about 20 percent of the amount of fuel required to ship the total production from all existing, projected and proposed mines. Coal trains would emit diesel fumes and coal dust, the effects of which are discussed in chapter IV, Air Quality.

Increased population associated with the proposed mines would cause more vehicle use in the study area, thus increasing pollutants from automobiles. These emissions would be aggravated by rail crossing delays, especially in cities, where long lines of idling vehicles would form. The overall effect of these secondary impacts cannot be quantified. (See Air Quality, chapter IV.)

b. Noise

Increased train frequencies would cause higher noise levels along the rail lines. Extra noise would be noticeable, but not particularly damaging, along the southern rail route; the increase would probably not be perceptible along the northern route. The increased rail traffic would widen a zone along these rail corridors within which noise levels would exceed the goal set by the U.S. Environmental Protection Agency (EPA) for the protection of human health and welfare. This goal is 55

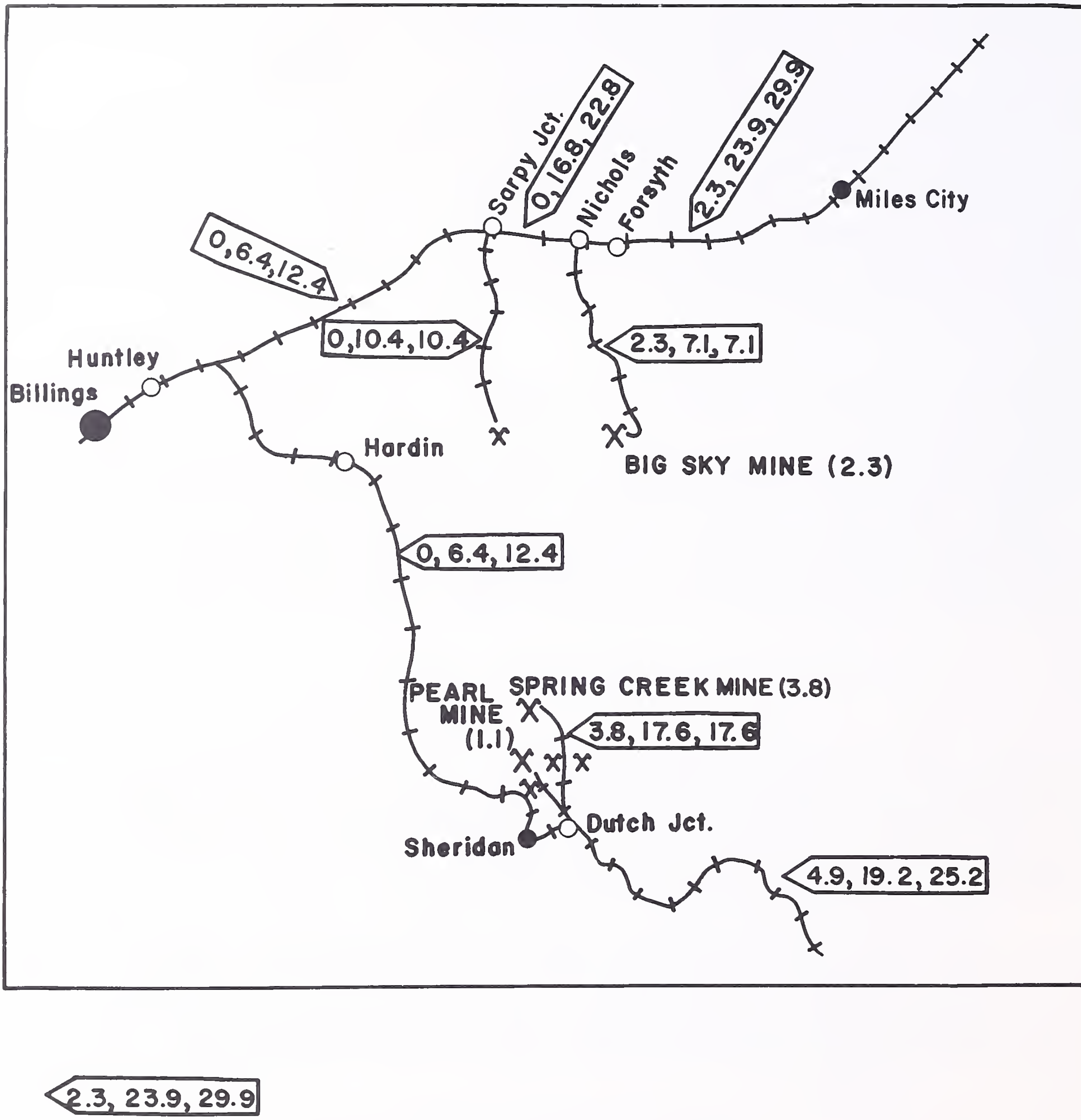


FIGURE IV-16.--Projected train traffic in the study area by 1990. First number in series shows number of coal trains per day on that rail segment from the proposed mines (including returning empty trains). Second number in series shows total coal train traffic. Third number shows all rail traffic including current (1978) level of general traffic.

L_{dn} (55 decibels weighted on a day-night basis); the noise varies with the amount and speed of rail traffic and the distance from the rail line. Persons living within these zones could expect some annoyance at rail noise, and could possibly experience hearing losses or behavioral changes under long-term exposure.

At Forsyth, the strip of land within which train noise probably exceeds the EPA standard is now approximately 750 feet wide (assuming train speed of 20 miles per hour). Coal traffic under baseline conditions would increase this strip to a little under 1,000 feet, or 500 feet on either side of the track. Rail traffic from the proposed Big Sky expansion would widen the strip about another 50 feet. Along the southern rail route, say at Gillette, the strip within which the EPA goal would be exceeded would increase 120 feet, from about 860, at present, to 980. Coal from these mines would not travel through the town of Sheridan.

4. Other Transportation Impacts

Increased population and commercial activity would increase demand for bus, airline, and rail service. Necessary expansion of airports would crowd facilities and increase public costs. Because commercial carriers can generally expand service to meet demands, increased demand might improve service to the region by making possible expanded schedules and newer equipment.

5. Transportation Impacts on Indian Reservations

On the Crow Reservation, traffic due to the proposed mines would increase slightly, mainly on I-90 and U.S. 212. On the Northern Cheyenne Reservation, traffic would increase slightly on Route 39 between the Big Sky mine and Lame Deer. Increased travel between the Colstrip and Decker areas would probably by-pass the Northern Cheyenne Indian Reservation to the east through Birney and Ashland.

Coal from the proposed mines would probably not be routed on the rail line crossing the Crow reservation.

M. RECREATION

The proposed developments would cause relatively minor direct impacts on recreation: the minesites and much of the surrounding region are privately owned and thus little used for recreation, except for occasional hunting and snowmobiling. The developments would not disturb any developed recreation facilities. The developments would, however, have moderate impacts on recreation through their contribution to regional population increases. These increases would probably reduce levels of recreation enjoyment, especially for long-term residents and visitors. They would be aware of increased crowding and of increased litter and local pollution at and near developed outdoor recreation facilities.

Similarly, population increases and the decreased average age of the regional population would stress urban recreational facilities in Forsyth and Sheridan.

The Pearl and Spring Creek mines would contribute about one-fourth of the anticipated population growth around Decker and Sheridan, and would contribute accordingly to demands on urban facilities in Sheridan County and outdoor facilities in the Big Horn National Forest and at the Tongue River Reservoir. For the Sheridan and Tongue River facilities, demands currently exceed capacity, and facilities would need increased maintenance and expansion to adequately meet anticipated demands. No plans for expansion of facilities at the Tongue River Reservoir are known, although Sheridan plans to expand its facilities.

The new town of Spring Creek would have recreation facilities, but it is not known whether they would be adequate to serve its population. Some residents of the new town would probably use facilities in Sheridan, and would contribute to problems of overuse there.

The Big Sky expansion and Colstrip units 3 and 4 would contribute as much as half of the population growth around Colstrip, and would contribute accordingly to demands on outdoor facilities in the Custer National Forest and on urban facilities in Colstrip and Forsyth. Forsyth's facilities would require extensive maintenance and possibly modest expansion to meet the anticipated demands. Colstrip's facilities would probably be adequate except from about 1980 to 1984, when most of the construction workers for the generating units would be living there.

N. CULTURAL RESOURCES

Impacts to cultural resources cannot be fully assessed because inventories have not yet been completed. On the basis of current information, it is anticipated that the proposed developments would probably have relatively minor impacts on the cultural resources of the region. Provisions for the study and protection of specific sites are discussed in the site-specific EIS's on the proposed mines. Occasionally, however, there would be inadvertent or illegal losses, notably of projectile points, tools, and other artifacts important for analyzing the prehistory of the Northern Great Plains. Losses would probably be most severe at the Big Sky and Spring Creek minesites, because artifacts are most densely concentrated there. Corresponding losses would probably be somewhat less severe at the Pearl site. Because of their relatively widespread availability, however, comparable resources could generally be studied elsewhere. But the context in which disturbed sites are related to the surrounding environment would be lost (e.g., for rock shelters and medicine wheels), and that loss could not be mitigated through data collection. In general, the proposed mines would result in the study of archeological sites that might otherwise not be studied for many years. There would be no direct impacts due to generating units 3 and 4, because they would occupy areas previously disturbed by mining.

However, the increase in regional population would increase unauthorized collecting and vandalism, especially near Colstrip and the new town, where most of the new population due to the proposed developments would be concentrated. Rock art, being highly visible, would be especially susceptible to vandalism.

Impacts on old homesteads are expected to be relatively insignificant: only a few homesteads would probably be affected by mining, and none of the homesteads is believed to have unusual historic significance. The proposed mines would impact historic battlefields only negligibly--through mining-induced regional population increases.

The known distribution of sites in the region suggests that perhaps 40 or so sites of undetermined types will be impacted by ongoing and projected mines. Most of the new projected mines will be on private lands over privately-owned coal, where regulations protecting artifacts are less stringent.

O. ESTHETICS

No areas of outstanding or even above-average scenery are expected to be mined. The visual impacts of the three proposed mines would be about the same as those of most other mines in the region. Generally, impacts would be confined to the immediate mine area, but the proposed Big Sky expansion would add to the impacts of the ongoing Big Sky mine, and the Pearl mine would add to the impacts of the ongoing Ash Creek mine. The visual impact of the generating units would be relatively insignificant because they would merely add to the impacts of the existing generating complex. For the most part, visual impacts would be experienced only by people visiting the mines. None of the proposed developments would disturb esthetically distinctive ("excellent," or class A) landscapes.

During mining, the most adverse (although temporary) visual impact would be at the Big Sky mine because the mine is readily visible (foreground zone) from FAS route 315. After mining, the most adverse visual impact would be at the Spring Creek mine because the central bluffs would be completely removed and replaced by a surface with considerably less relief, thereby reducing the scenic quality of the area. This impact would be permanent. However, the impact there would be less significant because the mine is "average" (class C), and it would not be readily visible (seldom-seen zone) from any highway.

Adverse visual impacts from the Pearl mine would be relatively insignificant both during and after mining because the mine would not be readily visible (seldom-seen zone) from any major highway, and the topography would not be markedly altered after reclamation. Similarly, topographic features of interest near the Big Sky mine would not be markedly disturbed after reclamation.

During mining, powerlines and transportation corridors to the Pearl and Spring Creek mines would create distinct artificial lines on the

order of 10 to 15 miles long. Industrial noises and odors would dominate the minesites. These would tend to be the worst in the Pearl and Spring Creek mines, where there is currently no industrial influence. These impacts would end when mining ends.

Several projected mines are expected to be developed within sight of the highway near Decker, that would contribute to further visual impacts along this route. Dust and gases from these mines would be annoying during winter air stagnations. Other projected mines would be farther from major roads and will be less noticeable. People living close to these mines, and the relatively few people who use the sites for recreation, would be most affected.

CHAPTER V

UNAVOIDABLE ADVERSE IMPACTS

Impacts on air quality would be significant during the lives of the proposed mines. The National Ambient Air Quality Standards for total suspended particulates would be violated in limited areas of public access near the mines. Colstrip generating units 3 and 4, as currently proposed, would meet applicable air-quality standards. Damage to vegetation from the units would probably be detectable but slight, and would be largely confined to a 4-mile radius of the units.

The proposed mines would account for about 3,000 of the 23,000 acres expected to be disturbed by mining by 1990. Most of the disturbance would be clustered around Colstrip and Decker; impacts on land use (primarily for livestock grazing and wildlife) would not be significant from a regional perspective. The mines would locally destroy soil structure and reduce soil stability; as a result, vegetative productivity on the reclaimed minesites would be slightly reduced for decades following an initial few years of adequate growth. The strong possibility of a decrease in precipitation suggests that establishing a self-sustaining vegetative cover for the long term would be difficult. The reclaimed lands would probably require specialized management for decades.

The reclaimed land, less diverse in vegetation, soils, and topography, would significantly reduce local wildlife populations for mine life and probably for several decades after mining. During mining, animals would be displaced to adjacent areas, which are probably near their carrying capacities; this would substantially decrease wildlife populations and reproduction rates, particularly for antelope and sage grouse. Several hundred antelope would probably be lost during the first severe winter in the Decker area, primarily as a result of the Spring Creek mine. The uses of wildlife for hunting and viewing in the Decker area would be substantially reduced for decades.

The proposed developments would contribute to a continuation of the social impacts induced by rapid population growth and fluctuations during the past decade. They would account for about half of the area's population growth by 1990. Construction of generating units 3 and 4 would account for most of the severe impacts in Colstrip and Forsyth from 1980 to 1984 (comparable to the impacts of constructing generating units 1 and 2 from 1973 to 1976). The proposed mines would have impacts comparable to those of other large strip mines in the West; they would account for about one-third of the growth in the projected new town near Decker, and they would contribute slightly to the moderate impacts in Sheridan. The rapidity of change--to which the proposed developments would contribute--would have its most serious impacts on ranchers, transient newcomers, school-age children, the poor, the elderly, and minorities. Long-time residents (including ranchers, some townspeople, and Indians of the Northern Cheyenne and Crow tribes) would see a continued disturbing change in their traditional ways of life, although most of these changes would probably happen even without the proposed developments. Stresses caused primarily by rapid

growth in population associated directly with the proposed developments would cause increased incidence of crime, alcohol and drug abuse, and abusive behavior; population growth would also help cause housing shortages and drive up prices beyond what would otherwise be expected.

The employment growth due to the construction of Colstrip generating units 3 and 4 would create temporary fiscal problems for Colstrip and Forsyth and their school districts. Sheridan County and its school districts would also have fiscal problems, but the proposed mines would contribute little to these impacts if the new town in Big Horn County were built. Population increases and the decreased average age of the regional population would stress urban recreation facilities in Forsyth and Sheridan.

The indirect effects of coal trains on land uses along the rail corridor would be moderately significant during mine life. Coal trains would increase traffic hazards at grade crossings near Decker, Colstrip, Forsyth, and eastward along the main lines. Noise and coal dust would noticeably increase in towns along the shipping routes.

Despite mitigating measures, some paleontological and archeological resources would likely be lost. No fossils or artifacts of high scientific value are expected to be lost.

Adverse impacts on esthetics would be unavoidable. Esthetic impacts would be locally severe, but they would not be regionally significant because the minesites are not of high or unusual esthetic value, nor are they visible to large numbers of people.

CHAPTER VI

SHORT-TERM USES VS. LONG-TERM PRODUCTIVITY

This chapter emphasizes when the impacts would occur in an attempt to determine how much the proposals would impede future use of the various resources.

The proposed mines would recover about 140 million tons of coal by 1990 and 250 million tons during their projected lives. This would account for about 22 percent of the coal mined in the designated region and adjacent areas by 1990. In 1982, the three proposed mines would produce about three-fourths as much coal as was produced in 1977 by the area's four existing mines. The coal would be used to generate electricity in Minnesota and Texas.

During their lives, the proposed generating units would slightly reduce vegetative productivity within about 4 miles of the units and possibly farther. The proposed mines would violate particulate standards within a few miles of the leaseholds, and would similarly reduce vegetative productivity. Because of decreased productivity, ranchers in the vicinity of the mines and generating units would experience slightly increased costs.

During their lives, the proposed generating units would use 22,000 acre-feet of water per year from the Yellowstone River, well within Montana Power Company's existing water reservation of 181,000 acre-feet per year. Both during and after their lives, the proposed mines would lower ground water levels within a mile or two of each mine. Gradual long-term degradation of ground-water quality is possible; a best guess is that the degradation would be local and slight. Similarly, impacts on surface water would mostly be limited to a slight increase in sedimentation, and a slight increase in sewage effluents in the major streams of the area due to mining-related population growth.

Reclaimed soils would probably support adequate vegetation for the first few years after reclamation. But the strong possibility of a decrease in precipitation during periodic droughts (see Climate, chapter II) suggests that long-term vegetative productivity might well be less than present productivity; land use for grazing and wildlife might be curtailed accordingly. Reclaimed areas would require specialized management for many decades; management practices that would be acceptable in nearby unmined lands could well cause soil compaction, erosion, and loss of productivity on the reclaimed minesites. With proper management, the reclaimed mines would probably support about the same level of grazing as was possible before mining. The reclaimed minesites would not support nearly as many game animals as before mining. Antelope populations in the Decker area would be reduced beyond the minesites for the long term due to lowered carrying capacity.

During their lives, the proposed Pearl and Spring Creek mines would improve fiscal conditions in Big Horn County, assuming that a new town

would be sited near Decker. The proposed mines would contribute slightly to fiscal impacts in Sheridan. Construction of the proposed generating units would severely strain fiscal conditions in Colstrip and Forsyth. Upgrading of community services and transportation and recreational facilities might well lag behind demands by a few years, but it would improve systems for future demands.

Rosebud, Big Horn, and Sheridan Counties would grow rapidly through 1990, although the proposed developments would contribute negligibly to growth in Sheridan County if the new town in Big Horn County were built. The decade or so of rapid growth due to construction of the generating units would likely be followed by a relatively minor economic bust cycle in Colstrip and Forsyth. New mines and generating units would provide a labor force and concentration of capital which would make further coal development likely, perhaps postponing (and worsening the effects of) any eventual bust periods.

About 76 archeological sites would be studied in the near future, in advance of mining; considerable information would be gained, but some information would be lost in the long term, because the option for in-place study by more advanced techniques would be lost.

CHAPTER VII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

This chapter briefly considers the resources that would be lost to other uses if the proposals were approved.

Uses of resources by the three proposed mines and two proposed generating units would be comparable to the use at other concurrent mines in the region. The three mines would use about 2.5 million gallons of diesel fuel, 100 thousand gallons of gasoline, and 75 million kilowatt-hours of electricity annually. The mines would use about 200 acre-feet of water each year, although much of this water would eventually return to the hydrologic system. The generating units would consumptively use far more water: about 22,000 acre-feet per year, mostly for cooling.

Mining and construction would cause about the same number of accidents as other western strip mines and large construction projects: for example, about 1,800 injuries (minor and serious) and eight deaths during the span of the mines.

By 1990, the proposed mines would recover about 140 million tons of the 32 billion tons of strippable coal in the northern Powder River basin; about 15 million tons would be left unrecovered, owing to limitations of present technology. The proposed mines and associated developments would use a negligible amount of water from the Tongue River system. The proposed generating units would use less than 2 percent of the discharge of the Yellowstone River at the Montana-North Dakota State line; and it would not conflict appreciably with anticipated downstream uses. The companies would be required to replace any wells lost near the mines.

The proposed generating units would contribute significantly to maintaining the Colstrip vicinity as a nonattainment area for air quality, and could well limit opportunities for further industrial expansion in that area.

The reduction in livestock use on the 3,000 acres expected to be mined by 1990 would not be permanent; following reclamation, the mines under sound management would probably support about the same number of livestock as was possible before mining. Those wildlife species which depend on sagebrush and ponderosa pine habitats, however, would be largely eliminated from the minesites for decades after reclamation. A small number of springs and seeps near the mines would be lost, which would contribute to local reductions in wildlife carrying capacity.

The proposed developments would cause fiscal problems in Colstrip, Forsyth, the new town, and to a limited extent in Sheridan; however, those problems would largely ease by 1990 as tax revenues from the developments increased. The proposals would continue the change from a rural and agricultural society to a more urban and industrial society; this change would last at least as long as mining continues in the area. The population of Rosebud and Big Horn Counties would increase and would probably remain much higher than at present. This would increase pressure

on urban and outdoor recreation facilities, and would increase hunting and fishing pressure.

The proposed mines would result in the near-future excavation of 76 known archeological sites. It is quite possible that they would result in the inadvertent loss of a few additional unknown sites.

The 400-odd acres of land used for new residential development would be permanently removed from agricultural and wildlife uses. New transportation corridors would similarly affect about 300 additional acres. The new town near Decker, in which many of the workers at the proposed mines would live, would interrupt use of important antelope winter range near the town.

CHAPTER VIII

ALTERNATIVES TO APPROVING THE DEVELOPMENTS AS PROPOSED

This chapter considers administrative and technical alternatives to approval of the mining and reclamation plans as proposed. Technical alternatives are more fully discussed in the site-specific EIS's for the proposed mines: DES 78-51 (Big Sky expansion), FES 79-12 (Spring Creek mine), and volume II of this EIS (Pearl mine).

A. INTRODUCTION

The production level evaluated as most probable (see ch. IV) is dependent in part on Federal and State approval of mine plans on existing Federal leases, State approval of mine plans on existing private leases, and, in some cases, Federal approval of short-term competitive leases under agreed-upon criteria. However, the Secretary of the Interior and the Commissioner of State Lands are not proposing a particular production level for coal in this EIS region; it is not within their authority to do so. Instead, they are considering actions within their authority that will allow Federal and private coal to be available where needed and under environmentally acceptable conditions to meet market demands and the energy needs of the nation. The approval actions under review at this time are being considered in this context.

In this regional EIS, decisions regarding mine plans and coal-related actions are considered on a regional or subregional basis. Related site-specific statements (previously released or accompanying this document) evaluate alternatives specific to the individual coal mine proposals. Thus, alternatives to the mine plans and coal-related actions are evaluated on an aggregate basis in this statement, providing a means of responding to regional or subregional environmental problems or social and economic concerns.

The Secretary's action in regard to the mine plans under consideration in this EIS may be: approval as proposed, rejection on various environmental or other grounds, approval in part, or approval subject to such additional requirements or modifications as he may impose under existing laws and regulations. He may also defer decision pending submittal of additional data, completion of required studies, or for other specific reasons. If there are serious environmental concerns as to the coal development, the Secretary may exercise his exchange authority as to the Federal coal rights or he may seek Congressional action cancelling the Federal leases involved.

Review of the Federal coal leases and the mine plans included in this statement indicates that the following administrative alternatives are appropriate for consideration: no action, approval as currently proposed (see chapter IV), and approval subject to specific modifications or requirements. To date, analysis has not indicated significant environmental grounds or any other reason that would suggest the need to defer decision on these proposals. Alternative sites for surface facilities,

mining technology and methods, coal transport methods, and rates of production on individual operations are considered where appropriate, but no such modifications have been proposed or identified which would significantly reduce the adverse impacts of coal production from these lands. Any new alternatives surfaced by the review process will be carefully considered.

Development of alternative sources of energy, energy conservation, Federal development of the coal, and emphasis on coal development in other regions of the U.S. are more appropriate for consideration on a program rather than a regional basis. These evaluations were made in the previous coal programmatic statement and are updated and revised as necessary in the new coal programmatic statement (FES 79-19).

A "best estimate" as to the probable production level was used as a basis for evaluation of cumulative impacts from coal development within the region. Actual production levels attained will depend on demands as well as availability of the coal. Factors influencing production levels in this region include access and economics in relation to other coal sources, transportation, local and State as well as Federal approvals, and pollution control requirements and technology. As previously indicated, with 47 percent of the coal in non-Federal ownership, availability of the coal resource to meet market demands or production could well occur at a significantly lower or higher level than the identified probable level. These alternative production scenarios, evaluated below, indicate areas of environmental concern or impact sensitivity.

Within this chapter, the projected Nance mine along the Tongue River near Birney is highlighted to the extent that it would add to impacts from the proposed developments. A formal permit application for the Nance mine will probably be submitted to the Montana Dept. of State Lands within the next year; thus, it is possible to examine this mine in more detail than other projected mines. The discussion focuses on the regional implications of the Nance mine; site-specific analyses will be made in an EIS on the forthcoming mine plan.

B. LOW LEVEL OF PRODUCTION

The low level of coal production envisages nonapproval or rejection of the pending mine plans on Federal leases along with related permits or rights-of-way. It would not affect continued development of non-Federal coal or Federal coal being produced on leases for which mine plans have already been approved. However, Federal coal could be made available under approved short-term competitive standards to maintain ongoing coal development.

Under the low level, the three proposed mines and two generating units would not be approved, but other coal mines would be developed to meet anticipated demand from the region. The low level is a projection of possible impacts in the absence of the proposed developments (if there

were no Federal action). It assumes a considerably lower overall level of development in the six-county study area. Several of the mines projected in the following analysis include or adjoin alluvial deposits. If such areas are designated as alluvial valley floors (see chapter III), production levels and environmental impacts might well be quite different from those postulated below.

Within and adjacent to the designated region, existing mines would continue operation, except that the Big Sky mine would run out of coal in 1979. There would be no new Federal leasing. To meet anticipated demands for coal, several new mines would develop State and privately owned coal. None of these projected mines have been formally proposed, and their inclusion here in no way implies approval of any forthcoming mine plans.

Cumulative production from mines within and adjacent to the designated region from 1979 through 1990 would be about 560 million tons. Production from existing mines within the designated region would peak at 28 million tons/year (mty) in 1979 and would decline to 18 mty by 1990 (table VIII-1). Three new mines would open in the region. Area C of Western Energy Company's Rosebud mine would supply Colstrip generating units 1 and 2 and meet contracted sales. Consolidation Coal Company would open the CX Ranch mine about 3 miles west of Decker. MONTCO's Nance mine would open along the Tongue River northeast of Birney, and would be connected to the existing Colstrip rail spur via a 44-mile-long rail line. The Nance mine is included in both the low and high levels of coal production: in the low level, because of the assumed demand for privately owned coal; in the high level, because of the assumed high demand for coal from both private and Federal leases. Ongoing and projected mines within the designated region would produce about 36 mty in 1985 and 39 mty in 1990.

TABLE VIII-1.--Low level of production in the Northern Powder River Basin (1978-90)

[Million tons per year]

	1978	1980	1985	1990
Designated region				
Existing and approved mines----	25.5	22.3	23.0	18.2
Projected additional mines-----	0	1.0	13.3	21.1
Subtotal--------------------	25.5	23.3	36.3	39.3
Adjacent areas				
Existing and approved mines----	7.4	10.0	12.5	13.8
Projected additional mines-----	0	2.0	2.0	2.0
Subtotal--------------------	7.4	12.0	14.5	15.8
Total--------------------	32.9	35.3	50.8	55.1

Existing mines outside the designated region would produce about 14 mty by 1990. Two projected new mines in Sheridan County (locations shown in fig. II-29) would produce about 1 mty each.

All the mines in and adjacent to the designated region would produce about 51 mty in 1985 and 55 mty in 1990 (table VIII-1). The ensuing analysis based on the above assumptions suggests what would happen if the proposed mines and generating units were not approved.

<u>Summary of impacts</u>.--The low production level would introduce impacts to a previously undisturbed area--in our assumptions, the Tongue River Valley near Birney (fig. I-1). Within the study area approximately 35 percent less coal would be mined than under the intermediate production level (a cumulative total of 560 million tons vs. 900 million tons) and about 30 percent less land would be disturbed (16,000 acres vs. 23,000 acres). Only 45 percent as much water would be used in the absence of generating units 3 and 4. Wildlife impacts would be less severe than under the intermediate level of development, largely because highly important wildlife habitat on the Spring Creek and Rosebud Area D minesites would not be disturbed. The rail spur to the Nance mine would cross high-priority wildlife habitat, however, and the CX Ranch mine would impinge on crucial areas within antelope and mule deer winter ranges. The low production level would introduce about 90 percent (76,000 vs. 82,000) as many people to the study area by 1990 as the intermediate production level, so social impacts due to rapid population growth would probably be somewhat less severe regionally and in Colstrip and Forsyth but they might be somewhat more severe in Sheridan in the absence of the new town. About 250 fewer Crow Indians would find employment. Rosebud County would experience a fiscal time lag due to the Nance mine. About 10 percent more acres would be disturbed per million tons of coal mined (about 19 vs. 17 acres per million tons). There would be about 40 percent fewer coal trains through the area. Cultural resources have not been surveyed, but impacts might well be greater than those under the intermediate production level because protection would be less stringent. Similarly, esthetic impacts would probably be at least as great as under the intermediate production level, because the Nance mine would be in a previously undisturbed part of the area.

The following impacts must be considered as representative--the sorts of things that would probably happen if the proposals were not approved: specific impacts cannot be forecast because alternative developments have not been formally proposed. General impacts (those not related to specific developments) are considered in chapter IV and are not repeated here.

The projected Nance mine along the Tongue River would not be within the existing mining clusters around Colstrip and Decker. A rail spur or branch line would be built to the minesite, increasing the possibility that new mines would open along the line. The rail line's profitability might well depend on the opening of additional mines along the Tongue River. (See High Level.) If the rail line were extended to the existing Decker spur, it could induce a new industrial cluster much like those found

along freeways. Impacts from the Nance mine would thus extend well beyond the minesite.

1. Geology

Under this production level, fewer mines would be opened in the Decker subregion and fewer acres would be disturbed. As a result, less sediment would reach the Tongue River--too little to significantly decrease water quality. Only if minesites were subjected to severe erosion would large amounts of sediment be added to the Tongue River.

The probability of successful reclamation at the Nance mine cannot be predicted in the absence of a detailed mine plan and baseline studies. If the reclamation surface were geomorphically stable, impacts would be minimal, although it would still be subject to the increased erosion common to minesites in the area. (See Geology, chapter IV.) If the reclamation surface were not geomorphically stable, erosion could be severe. Much of the excess sediment would be transported to the nearby Tongue River, where it could reduce water quality. If gullies formed on the reclamation surface, either from the spread of naturally-occurring gullies or as a result of reclamation, they could continue to spread upstream into the adjacent proposed Tongue River Breaks wilderness area.

2. Hydrology

Impacts on water resources under the low level of production would not differ significantly from those under the baseline production level. (See chapter II.) Water use in mining and associated activities would be about 17,800 acre-feet annually by 1990. This would be about 44 percent of the water required under the intermediate level (figs. IV-1 and IV-2).

The Nance mine would probably not contribute significant contamination to the Tongue River or to its alluvium due to leaching from the mine spoils. Similarly, the CX Ranch mine would have no significant impact on the hydrology. The Nance mine, however, has the potential to affect the Tongue River. Woessner (1979), after modeling a hypothetical mine along the Tongue River in the Knobloch coal seam found that such a mine would have "a measurable impact on the regional groundwater quality and a significant impact on the quality of the Tongue River. A large percentage of the leachate constituents in the spoil area will be removed by the first pore volume of water through the mine area. However, water quality impacts will last for hundreds of years."

Construction of the Colstrip-Nance railroad would yield negligible sediment because of required reclamation and control. Also, most stream crossings would be on ephemeral streams. Crossings of Rosebud Creek and the Tongue River would be constructed so as to prevent sediment from reaching the streams after reclamation.

Sediment yield from the ongoing and projected mines would not be a significant impact because little if any sediment would reach perennial streams.

3. Climate

The mines and existing generating units would cause minor, mostly local changes in the quality and quantity of precipitation similar to those described in chapter IV.

4. Air Quality

a. Emissions from area sources

The low level of production would increase population-related air pollution in Colstrip, Forsyth, and Sheridan (table VIII-2). The greatest percent increase would be in Colstrip, largely due to workers from the Nance mine. Population-related emissions in Colstrip would not differ significantly from those of the intermediate level, except from 1980 to 1982, during which time the construction of units 3 and 4 would not occur and emissions would be 45 percent lower.

TABLE VIII-2.--Percent change in population-related air pollution, low level of production

Town	Percent change from baseline	
	1985	1990
Colstrip----	+10	+11
Forsyth-----	+4	-2
Hardin------	-16	-14
Sheridan----	+5	+5

Emissions from internal-combustion engines and blasting at the minesites near Colstrip would be at least 45 percent less than the baseline. In the Decker area these emissions would be similar to baseline conditions with the exception of possible additional emissions from the CX Ranch mine (table VIII-3). Mean annual carbon monoxide and nitrogen oxide concentrations in Colstrip and Birney would be insignificant. By 1990, diesel emissions could cause annoying odors in Birney.

In 1985 train traffic from Colstrip through Forsyth would be the same as for the intermediate production level, so locomotive diesel emissions and coal dusting would be the same as for the intermediate level. Nitrogen dioxide emissions from trains from the Nance mine along the railroad spur from Birney to Colstrip would be 14 tons/mile/year. Coal dust emissions would be within a range from 0.4 tons/mile to 700 tons/mile annually. From the Decker area south past Sheridan, nitrogen oxide emissions would be 18.9 tons/mile/year and coal dust emissions would be within a range of 1 ton/mile/year to 3,000 tons/mile/year.

TABLE VIII-3.--Predicted emissions from minesite internal-combustion engines and blasting during 1985 (tons/yr)

	CO	NO_x	SO_2	HC	HCN	Aldehydes	Particulates
CONSOL CX Ranch							
Diesel----------	88.5	377.1	28.1	38.0	---	8.7	24.6
Gasoline--------	5.0	.4	---	.4	---	---	.04
ANFO------------	30.0	27.0	---	---	.1	---	---
MONTCO Nance Ranch							
Diesel----------	79.3	356.2	26.5	35.9	---	8.2	23.0
Gasoline--------	100.3	7.4	.2	7.9	---	---	.8
ANFO------------	71.4	60.0	---	---	.2	---	---

b. Emissions from Colstrip units 1 and 2

Sulfur dioxide and nitrogen oxide (NO_x) emissions from units 1 and 2 would increase because of the lower Btu content and higher sulfur content of Area C coal. (See Air Quality, Future Environment, chapter II.) Particulate emissions would vary with ash content of coal and this variance is unknown. The NSPS for NO_x would be violated periodically.

c. Ambient particulate concentrations

Near Colstrip, the area affected by elevated TSP concentrations and dustfall rates would be about 50 percent less than under the intermediate level (estimated from 1978 model). Cumulative effects from both the Rosebud and Big Sky mines would not occur. Violations of the TSP and dustfall standards would be confined to the Rosebud Area C mine and downwind of both the Area A loadout and the generating unit coal-handling facilities. The annual geometric mean TSP concentration in Colstrip would be slightly less than the 1990 concentration predicted for the intermediate production level (since Area D would not be mined and coal-handling facilities for units 3 and 4 would not be operating). Since the Big Sky mine contributes only 1 $\mu g/m^3$ annually to the town of Colstrip, its absence would negligibly reduce fugitive dust in Colstrip.

Near Decker, particulate concentrations would be the same per unit volume as the baseline condition except that the Welch, Whitney, and CX Ranch mines would increase the area affected by approxiately 25 percent.

Fugitive dust emissions from the Nance mine were modeled for a time when mining was directly east of Birney and the coal extraction rate reached 12 million tons annually (fig. VIII-1). In Birney, the annual geometric mean TSP concentration would be 12.5 $\mu g/m^3$ above baseline and the second highest 24-hour maximum TSP concentration would be 121 $\mu g/m^3$. Both values would violate the Class I air-quality increments for PSD. (See chapter III.)

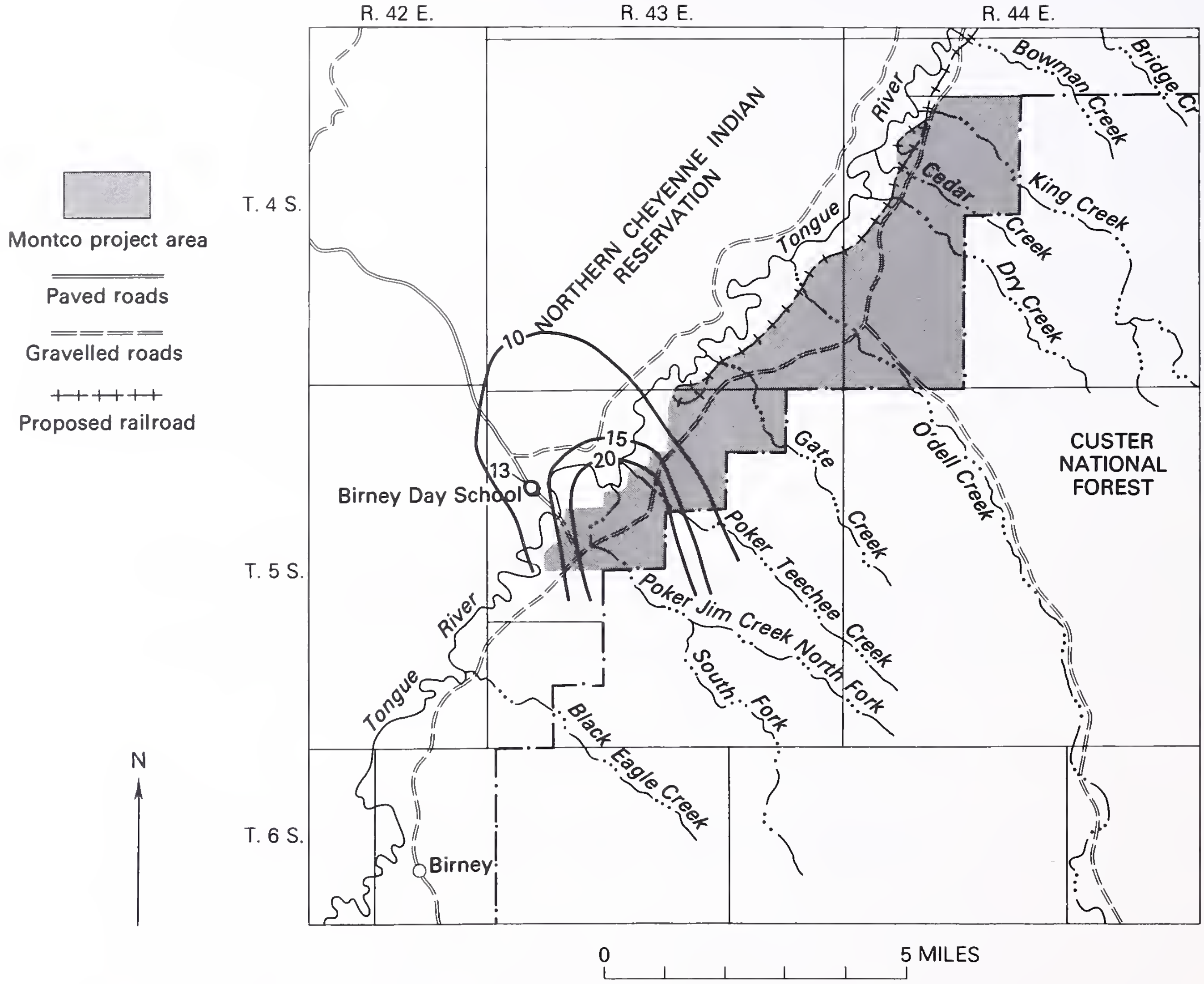


FIGURE VIII-1.-- Annual geometric mean TSP ($\mu g/m^3$) on the Northern Cheyenne Reservation during 1990 from Nance mine dust emissions— low and high levels of coal production. Background is not plotted.

5. Soils and Vegetation

Approximately 10,000 acres of soils and the vegetation it supports would be disturbed by 1990. These lands would be reclaimed, and the success of reclamation would depend on the nature of the minesites and the specifics of the mine plans. Impacts would generally be similar to those described in Soils and Vegetation, chapter IV.

Soils information for the Nance minesite, although incomplete, indicates potential problems due to adverse texture (excess clay or sand), rock content, alkalinity, and sodium and clay mineralogy. Preliminary baseline studies of portions of the minesite show that much of the overburden exceeds State suspect levels for sodium-adsorption-ratio (SAR) and nickel. Based on studies at other minesites in the area, molybdenum concentrations would likely exceed State suspect levels. Some strata exceed suspect levels for pH, conductivity (salinity), cadmium, and manganese.

6. Wildlife

The important Spring Creek-Squirrel Creek mule deer winter range in the Decker subregion would be significantly less disturbed than under the intermediate level of development. Antelope winter ranges would also be less disturbed. Impacts on game birds and raptors would be less severe, although this would be offset by development of the Nance mine in a previously undisturbed part of the region.

Impacts due to the Nance mine and railroad cannot be predicted rigorously because data are sparse. Impacts on endangered species are unknown because these species have not been inventoried in this area. The following discussion is based on a section-by-section wildlife inventory by the Montana Department of Fish and Game in 1976. Most of the 5,000 acres that would be impacted by the Nance mine and railroad is classified as high-priority wildlife habitat. Depending on its location, the railroad between Rosebud Creek and Colstrip could preclude use of at least one sage grouse lek; it could also disturb three sharp-tailed grouse leks. The railroad would also cross one of four major antelope winter concentration areas in southern Rosebud County. Depending on the amount of coal train traffic and the fencing installed, use of that range by antelope could be restricted.

The mine area itself would be converted from native grassland to domestic vegetation, reducing its carrying capacity for big-game species. Activity at the mine would adversely affect adjacent mule deer winter range to the south and east on the Custer National Forest. Effects on fish in the Tongue River would depend on amounts on sediment entering the stream, which cannot be predicted in the absence on a detailed mine plan.

The CX Ranch mine would have more adverse impacts on wildlife than any other mine in the Decker subregion except the Spring Creek mine: it would

disrupt two crucial use areas within an important mule deer winter range; a crucial area within an antelope winter range; and portions of two white-tailed deer ranges. The mine would disrupt one active golden eagle nest, one prairie falcon nest, and potential nest sites for peregrine falcons.

7. Social Environment

The population of the six-county study area would increase from about 59,800 in 1979 to about 76,000 in 1990--about 6,000 less than under the intermediate production level. Except for Rosebud County, the percentage growth rate for the other five counties from 1980 to 1990 would be within 2 percent of their growth projected for the intermediate production level, and the number of newcomers to each county would differ by less than 500. Social problems probably would be concentrated in the Sheridan urban area because the new town in southern Big Horn County would not be built; newcomers would accordingly locate in Sheridan County instead of in Montana. Otherwise, social impacts would be generally as described in chapter IV. Rosebud County would grow by the greatest percentage, although it would grow less rapidly from 1980 to 1990 than it did from 1970 to 1980. Sheridan County would grow by the greatest number.

Growth would be concentrated in Colstrip (fig. IV-12); growth would be very rapid from 1981 to 1983, it would slow abruptly from 1983 to 1984, and it would stabilize at about 5 to 6 percent thereafter. Fluctuations in growth rate would be much less than under the intermediate level. The population would be about 500 more than the baseline population after 1981 and about 1,600 less than the intermediate level population after 1984. In Forsyth, the population would be about the same as under the baseline and about 1,000 less than under the intermediate production level. The population would grow about 9 percent from 1981 to 1982, the growth rate would decrease abruptly from 1983 to 1984, and it would stabilize at about 3 percent thereafter. Fluctuations in growth rate would be greater than under the baseline but less than under the intermediate level.

In Big Horn County, most of the growth would be in Hardin, which would grow about 5 percent per year. The population for the low production level would be about 500 less than for the intermediate level and about 900 less than for the baseline. Fluctuations in growth rate would be less than for either the baseline or intermediate levels.

Sheridan County would have the greatest number of newcomers. Most of the growth would be in the Sheridan urban area (fig. IV-12). The population for the low production level would be practically indistinguishable from the populations for the baseline and intermediate levels. Fluctuations in growth rate would be slightly lower for the low level than for the baseline or intermediate levels before 1981; after that, the growth rates would be practically the same--about 3 percent.

The population of Powder River County would grow rapidly, sharply reversing the trend of the past decade. The Nance mine would add about 1,700 people to the Ashland area by 1990. Custer and Treasure Counties would have little or no growth.

8. Economics

a. Employment

Approximately the same number of jobs would be created as under the intermediate production level, because the projected mining under the given assumptions would be more labor intensive than the proposed mines.

b. Income

The low level of production would not have an effect on income or poverty levels that is appreciably different from the baseline.

c. Taxation

Revenue and expenditure trends for local governments would not differ significantly from those of the baseline production level. In Big Horn and Sheridan Counties, revenues would generally increase faster than expenditures (tables VIII-4 and VIII-5). In Rosebud County, expenditures would generally increase faster than revenues (table VIII-6). Fiscal conditions in Powder River County would be the same as under the baseline, with expenditures generally increasing faster than revenues.

TABLE VIII-4.--Annual growth rates of revenues and spending, Big Horn County, Montana

[Percent]

Year	County		School district	
	Revenue	Spending	Revenue	Spending
1978---	25.4	0.5	3.8	0.8
1979---	17.9	-.1	7.2	-.1
1980---	.3	.3	.2	.5
1981---	14.2	1.2	6.6	1.8
1982---	4.0	.8	4.0	1.2
1983---	-.2	.9	.7	1.4
1984---	1.2	1.0	1.4	1.5
1985---	-.1	1.0	.9	1.6
1986---	.0	1.3	1.2	2.0
1987---	.0	.0	1.2	2.0
1988---	.0	1.4	1.3	2.1
1989---	.1	1.4	1.3	2.1
1990---	.4	3.9	4.0	6.1

TABLE VIII-5.--Annual growth rates of revenues and spending, Sheridan County, Wyoming

[Percent]

Year	County		School district	
	Revenue	Spending	Revenue	Spending
1978---	-.4	1.6	1.3	1.7
1979---	14.9	2.9	2.9	3.1
1980---	15.3	1.9	8.6	2.0
1981---	-.5	1.2	1.2	1.3
1982---	1.8	1.9	1.8	2.0
1983---	.8	1.7	1.6	1.8
1984---	1.1	1.8	1.7	1.9
1985---	1.1	1.8	1.7	1.9
1986---	1.3	2.2	2.0	2.3
1987---	1.2	2.2	2.1	2.3
1988---	1.3	2.2	2.1	2.4
1989---	1.3	.1	2.2	2.4
1990---	1.1	6.1	8.8	6.4

TABLE VIII-6.--Annual growth rates of revenues and spending, Rosebud County, Montana

[Percent]

Year	County		School district	
	Revenue	Spending	Revenue	Spending
1978----	-19.0	0.7	-8.8	1.0
1979----	-5.0	-.3	-1.4	-.5
1980----	-34.4	-.1	-4.9	-1.4
1981----	0.3	1.3	1.6	2.0
1982----	1.4	6.6	8.3	10.2
1983----	4.6	2.6	4.3	4.0
1984----	11.3	-.4	2.0	-.7
1985----	17.4	1.9	6.6	2.9
1986----	9.0	2.0	1.9	3.1
1987----	.2	1.7	2.0	2.6
1988----	.2	1.7	2.0	2.6
1989----	.2	1.7	2.0	2.6
1990----	.7	4.3	5.1	6.6

The only noticeable fiscal impacts resulting from the low production level would occur in Rosebud County from the Nance mine. Construction workers would begin arriving in Rosebud County in 1981, and reach a peak of 450 workers in 1982. The newcomers associated with the construction would require public goods and services. However, revenues generated from coal production would not be forthcoming until the opening of the mine in 1983. (See table VIII-6.) The shortage of revenue during this early period of construction might cause service shortfalls in the public goods sector along with financial management problems for local governments in Rosebud County.

d. Reservations

Crow--Approximately 105 members of the Crow tribe would be employed in mining, or about 240 fewer than under the baseline level of production (also chapter IV, since they are identical).

Northern Cheyenne--On the basis of past experience, it is assumed that 17 members of the Northern Cheyenne tribe might get mining jobs at the Nance mine (4 percent of the mine work force).

9. Community Services

Service needs in Sheridan would be similar to baseline conditions. Colstrip and Forsyth would experience little change from the current situation; these towns would not be impacted nearly as strongly as in the intermediate level because Colstrip units 3 and 4 would not be built. Ashland would have greatly increased service needs due to the Nance mine; its lack of prior experience with rapid growth could pose major problems in providing needed services.

10. Land Use

Existing, approved, and projected mines would use about 4,500 acres more land in 1985 and about 8,500 more acres in 1990 than in 1978 (fig. IV-14). New mine facilities would require about 1,750 acres. (It is assumed that each mine would require about 350 acres throughout its life.)

Population growth would require about 40 acres more residential land in 1985 than in 1978 and about 50 acres more in 1990 than in 1978. Most of this demand would fall in Sheridan and southern Big Horn Counties.

11. Transportation

In 1985, existing, approved, and projected mines in the designated region would export about 47 million tons of coal, requiring an average of 26 train trips per day (including returning empty trains). In 1990, they would export about 52 million tons, requiring an average of 28 train trips per day. (See figure IV-15.)

Because of anticipated population growth, there would be about 600 more registered motor vehicles in the region in 1985 and about 760 more

in 1990 than in 1978 (assuming that the current ratio of approximately 1 person per vehicle continues to apply). This would cause slight increases in traffic congestion and accident rates, especially in Colstrip and Forsyth.

Demand for commercial transportation services would probably increase slightly more rapidly than population growth.

12. Recreation

Recreation demands would be negligibly less than those for the intermediate production level. Outdoor recreation use in the Ashland area would increase due to the population influx from the Nance mine.

13. Cultural Resources

Impacts cannot be determined because cultural resources have not been inventoried on projected mines. But they might well be greater than under the intermediate production level because much of the projected mining would occur on private lands and minerals, where regulations protecting cultural resources are less stringent than for the proposed mines. The section 106 process for determining and protecting National Register sites is not required on private lands. What is known about prehistoric migration patterns also suggests the strong possibility of relatively abundant sites along major drainages, notably along the Tongue River, where the Nance mine would be located.

14. Esthetics

The Nance mine would disturb a relatively pristine area of the Tongue River valley; the mine would be highly visible from the road along the river north of Birney. The mine would also be an esthetic intrusion visible and audible from an adjacent proposed wilderness area on the Custer National Forest. Esthetic impacts near Colstrip and Decker would be slightly less than under the intermediate level.

C. HIGH LEVEL OF PRODUCTION

This level reflects the highest rate of coal mining and related development that could reasonably be expected to occur in and adjacent to the designated region under the prevailing political and economic environment. This level assumes that the market for coal would continue to expand, and that the existing transportation network would be adequate or could be upgraded to meet the demand. It assumes that new mines would be approved on existing Federal and State coal leases, but that there would be no major Federal leasing of new coal, so development of privately owned coal would be accelerated. This section, then, considers the impacts of the proposed developments in the context of a considerably higher level of concurrent development than that considered in chapters II and IV. In effect, it examines a worst-case scenario, in order to provide the basis for a decision as to whether the impacts of the proposals would be acceptable if they were added to the impacts of high concurrent coal production in the study area.

Projected production under the high level includes all production projected under the low and intermediate levels, plus a number of additional mines and related developments inside and adjacent to the designated region (table VIII-7). The projected developments assumed in the high level have not been formally proposed, and therefore are not extensively analyzed. They are included to provide a context for consideration of the three proposed mines and two proposed generating units. Specific assumptions follow.

TABLE VIII-7.--Highest probable level of coal production in the Northern Powder River Basin (1978-90)

[Million tons per year]

	1978	1980	1985	1990
Designated region				
Existing and approved mines---	25.5	31.3	23	18.2
Proposed mines----------------	0	6.0	13.2	13.2
Projected additional development-----------------	0	2.0	28.5	58.3
Subtotal------------------	25.5	39.3	64.7	89.7
Adjacent areas				
Existing and approved mines---	7.4	10.0	12.5	13.8
Project additional development-----------------	0	2.0	21.0	21.0
Subtotal------------------	7.4	12.0	33.5	34.8
Total-------------------	32.9	51.3	98.2	124.5

Private coal would be developed in the Otter Creek drainage. Two new mines would open at undetermined locations between Ashland and Colstrip along the projected railroad to the Nance mine. No such mines have actually been proposed, and no specific companies or tracts of land are assumed in the analysis.

The Moorhead Dam would be built on the Powder River, 4 miles north of the Montana-Wyoming border. The dam would create a reservoir about 30 miles long extending into Wyoming. Water from the reservoir would be used for irrigation and municipal supplies in Montana and Wyoming, and for a possible coal gasification plant near Gillette. Montana Power Company's 330-megawatt generating unit 5 would be built at Colstrip and

come on line in 1988; Pacific Power and Light Company's four 500-megawatt units would be built at Prairie Dog Creek; two of these units would come on line in 1987-88. These developments have not been formally proposed, and their consideration here in no way implies eventual approval.

Existing mines within and adjacent to the designated region would produce about 36 million tons in 1985 and about 32 million tons in 1990. Projected new mines in and adjacent to the region would produce 2 million tons in 1980, 50 million tons in 1985, and 79 mty by 1990 (table VIII-7).

Environmental impacts of the three proposed mines in the context of the high production level are discussed below.

Summary of impacts.--The proposed mines would produce about 140 million tons of the 1,070 million tons of coal mined in the study area by 1990. They would contribute to a possible slight increase in the sediment load of the Tongue River. The proposed mines would contribute to the need for minor adjustments in priorities for water use, mainly in the Tongue River Basin, notably in Sheridan. The proposed Colstrip generating units would contribute to periodic violations of the NO_x and SO_2 emissions standards and would add to emissions from the Prairie Dog Creek generating units. Impacts such as acid rain would be most likely in southwestern South Dakota, but relatively rare around Sheridan. The Pearl mine would add to high TSP concentrations due to the Ash Creek and CX Ranch mines. The proposed developments would contribute to population-induced social impacts especially in the new town and in Colstrip and Forsyth. But these impacts would probably be delayed somewhat compared to the intermediate production level because construction of Colstrip unit 5 would postpone sharp population fluctuations in Rosebud County. Fiscal impacts in Rosebud County due to the proposed mines would be somewhat reduced because of the generating units. Similarly, the Prairie Dog Creek generating units and the new town would cause revenues to increase faster than expenses in Sheridan. The proposed mines would account for about 3,000 acres of the 28,000 acres disturbed by all concurrent mining and derivative activities by 1990 (excluding the 20,000 acres under Moorhead Reservoir). The proposed mines would disturb less area per million tons of coal (15 acres) than the average for all concurrent mines (17 acres). The proposed mines would account for about 7 of the 60 coal trains per day.

---

1. Geology

Under this production level, there would be 11 mines in the Decker subregion. Even with successful reclamation, there might be a slight increase in the sediment load of the Tongue River. If reclamation proved unsuccessful and severe erosion occurred on the reclaimed minesites and spread upstream through unmined watersheds, much larger amounts of sediment would be added to the Tongue River.

Multiple minesites are proposed, on two tributaries in the Decker subregion, and the successful reclamation of these mines would be interdependent. (See Geology, chapter IV.)

The proposed mines would not contribute to either of the following impacts. Erosion at the Nance minesite could spread to the adjacent proposed wilderness area. (See Low Production Level.) Construction of the Moorhead dam and reservoir would reduce spring flood peaks and the sediment load of the Powder River downstream. River channel geometry might change, and stream incision might increase.

2. Hydrology

Water supplies would probably be adequate for immediate production at the high level, but might require minor adjustments in priorities, particularly in the Tongue River Basin. No measurable deterioration in surface water quality would occur at this level of production. The sediment yield from the additional mines would be controlled by State and Federal mining regulations and would not increase significantly.

Table VIII-8 shows projected water use in the study area for mining and associated activities by 1990.

TABLE VIII-8.--Projected consumptive water use related to mining in the study area, 1990

[Acre-feet]

Mining	1,280
Colstrip units 1 and 2	13,500
Colstrip units 3 and 4	22,100
Colstrip unit 5	6,800
Prairie Dog Creek (PP & L)	36,000
Towns	4,490
Evaporation from Prairie Dog Creek Reservoir	4,300
Total	88,470

Evaporation losses from Moorhead Reservoir would be 60,700 acre feet annually--21 percent of the average annual unappropriated flow of the Powder River Basin (U.S. Department of the Interior, 1975). Evaporation from the Moorhead Reservoir and consumptive use of the water for agriculture and industry would cause a significant reduction in flow in the river. With this loss, total water requirements would be 149,170 acre-feet annually by 1990--1.7 percent of the average annual discharge of the Yellowstone River at the Montana-North Dakota State line.

Water requirements at this level of production, exclusive of the evaporation losses from Moorhead Reservoir, would be about 47,900 acre-feet more than, or about 220 percent of, the water requirements at the intermediate level.

Sheridan may need more water. Withdrawals from the Tongue River for power plants on Prairie Dog Creek would amount to 37 percent of Wyoming's share of unappropriated water of the Tongue River.

Colstrip generating unit 5 would add as much as unit 1 or unit 2 to the impacts on hydrology.

The proposed developments would not contribute to any of the following impacts. The projected mines and associated railroad spurs near Otter Creek and along the Tongue River would probably cause only local impacts; for example, a minor increase in the total dissolved solids. (See discussion of the Nance mine under the low level.) Developments other than the proposed developments would increase the demand for water in Ashland by 120 acre-feet per year and in Broadus by 25 acre-feet per year. Both would have adequate supplies.

Pacific Power and Light Company would require storage for operating generating plants on Prairie Dog Creek. The company has filed for 36,000 acre-feet of storage on Prairie Dog Creek plus 8 cubic feet per second continuous diversions for consumptive use and 200 cubic feet per second surplus water from the Tongue River. Agricultural requirements would not be affected by forecasted industrial demands on the Tongue River system. But high flow would be reduced for an indeterminate time during spring runoff.

3. Climate

The potential for subtle changes in the quantity and quality of precipitation would be somewhat greater than in the intermediate level, primarily from the generating units at Prairie Dog Creek and from Colstrip units 1-5. The amount of carbon dioxide (CO_2) released would be about 250 million tons per year by 1990, about 36 percent greater than in the intermediate level.

4. Air Quality

Colstrip units 3-5 would periodically violate NO_x and SO_2 emission standards. They would add to the emissions in the Colstrip nonattainment area.

a. Emissions from area and mobile sources

Population-related air pollution would increase in Forsyth, Colstrip, the new town, and Sheridan (table VIII-9). The most impacted town would be Colstrip, where construction workers and employees for units 3, 4, and 5 plus additional employees of new mines in the Ashland-Birney area

TABLE VIII-9.--Percent change in population-related air pollution under the high level of production

Town	1980	1982	1985	1986	1990
Percent change from baseline					
Colstrip-----	---	+52	+47	+52	+44
Forsyth------	---	+35	+34	+34	+28
Hardin-------	+3	---	-9	---	24
Sheridan-----	+6	---	+9	---	+72
Percent change from intermediate					
Colstrip-----	---	+0.2	+16	+26	+20
Forsyth------	---	+4	+11	+13	+6
New town-----	+9	---	+31	---	+31
Hardin-------	+4	---	-4	---	-9
Sheridan-----	+1	---	+10	---	+13

would reside. (See Social Environment, high level.) Construction of Colstrip unit 5 would cause a second peak in population-related air pollution near Colstrip during 1986. Although mining in the Colstrip area would not increase significantly above the intermediate level (nor would related train-traffic emissions or internal-combustion emissions), population-related air pollution would continue to increase after 1985 due to employees of new mines in the Ashland-Birney area.

Fugitive dust from coal-handling facilities for Colstrip unit 5, increased mining in Area D, and resident population in Colstrip would increase, so particulate emissions from these area sources would have to be offset before the construction of Colstrip unit 5. Table VIII-10 shows conservatively what these emissions could total.

TABLE VIII-10.--Approximate 1990 particulate emissions associated with Colstrip generating unit 5

Source	Particulate emissions (tons/yr)
Area D, 1.5 x 10^6 tons------	280
Coal handling to unit 5-----	90
Population (unit 5)---------	42
Total--------------------	412

Unit coal train emissions from the Nance mine would be the same as those of the low production level. The mine on Otter Creek would increase these emissions by 41 percent--nitrogen oxides by 7.8 tons/mile/year and coal dust to a range of 0.2 to 400 tons/mile/year. These unit trains would pass through Forsyth, the most train-impacted town in the study area, where diesel odors and dust would become a public nuisance.

Population-related air pollution in the new town would increase by 31 percent after 1984, largely due to the CX Ranch mine.

Unit train nitrogen oxide emissions due to increased coal extraction south of the Decker area would be 28.1 tons/mile/year. Coal dust emissions along the railway corridor 50 miles to the south would range from 0.72 to 1,440 tons/mile/year.

b. Emissions from Colstrip units 1-5

Beginning in 1988, gaseous and particulate emissions from Colstrip units 1 through 5 would increase by 25 percent (table VIII-11). The revised EPA standards for SO_2 emissions and the NSPS for NO_x would periodically be violated by units 3 through 5, assuming existing control efficiencies. Emissions would be less under new controls recently proposed for units 3 and 4 by the company.

TABLE VIII-11.--Total gaseous emissions from Colstrip units 1 through 5, beginning in 1988

Emission	Tons/year
SO_2	104,515
NO_x	73,130
Fluorides (HF)	2.04
CO_2	22,400,000
Particulates	3,900

c. Emissions from Prairie Dog Creek generating units

Gaseous and particulate emissions from the projected 2,000-MW generating units would be similar to those predicted from Colstrip units 1 through 4 (2,100 MW). Two of the Prairie Dog Creek units would not come on line until after 1990, however. (See Air Quality, chapter IV.) Any differences in emissions would be due to differences between the coal from the Spring Creek mine (used here) and the coal from the Rosebud mine (used at Colstrip). Both wet scrubbers and electrostatic precipi-

tators would be used to control emissions from the PP & L units,[1] with uncertain control efficiency. Fine particulates would probably still escape control. (See Air Quality, chapter II).

Since prevailing winds in the Sheridan area are from the northwest, the town of Sheridan would rarely be impacted by the power plant plume. However, the units could affect weather patterns and rain chemistry when upper level winds of the Colstrip area are the same as those from the Decker area. Southwestern South Dakota would be the most likely location of acid rain (as "rainout") effects from the Colstrip and Prairie Dog Creek generating units' plumes (Renne and Elliott, 1976).

d. Total suspended particulates (TSP) and dustfall

By 1990, the Colstrip area TSP and dustfall rates would have increased most in the mobile home court, where dust from the coal mining in Area D and coal-handling facilities to unit 5 would add to the already high fugitive dust problem. (See Air Quality, chapter IV.) The annual geometric mean TSP concentration in Colstrip could increase to at least 60 $\mu g/m^3$ (model extrapolation). This would be 10 percent higher than the predicted intermediate TSP concentration.

Mining near Decker would increase the total area affected by elevated particulate concentrations by 80 square miles, 10 percent higher than the intermediate level prediction. Cumulative TSP and dustfall rates in the area between the CX Ranch and the Pearl-Ash Creek mines would also be higher. The range in TSP would be 40 to 50 $\mu g/m^3$, compared to approximately 5 $\mu g/m^3$ under the intermediate level.

Mining in the Ashland-Birney area would affect a relatively pristine airshed, in contrast to mining in the Decker and Colstrip areas where air quality is already degraded.

5. Soils and Vegetation

About 48,000 acres would be disturbed by 1990, approximately twice the disturbance in the intermediate level. Moorhead Reservoir would inundate 20,000 acres of riparian vegetation along the Powder River. The success of revegetation on the 27,000 acres directly disturbed by mining would depend on the conditions at the minesites and on the mine plans.

6. Wildlife

The CX Ranch mine would compound the severe impacts of the Spring Creek, Pearl, and nearby projected mines on antelope, and would worsen impacts on mule deer, due to disruption of crucial areas within winter ranges.

---

[1]Pacific Power and Light, 1978, oral commun. with Bob Peterson, Manager Environmental Services, Portland, Oregon, November 1978.

Other concurrent developments, notably the Nance mine, would make wildlife impacts more widespread in the designated region. Projected mines in the Otter Creek drainage and near the Tongue River (related to construction of the Nance railroad) would reduce carrying capacities for species requiring shrubs, trees, and other vegetation difficult to re-establish, and increase carrying capacity for species associated with grassland habitats. No known crucial wintering areas would be impacted, but some grouse leks would possibly be disturbed.

The Moorhead Reservoir would alter more habitat than any single mine. It would potentially disrupt wildlife use of riparian habitats for 190 miles downstream due to water fluctuations, and would inundate about 30 miles of riverine and riparian habitats. Irrigation water from the reservoir would allow cultivation of land with consequent loss of habitat. None of the proposed or projected mines would be in the Powder River drainage, however, so the reservoir would not compound adverse effects from these mines.

7. Social Environment

The population of the six-county study area would increase from about 59,800 in 1979 to about 88,000 in 1990--about 6,000 more than under the intermediate production level. Social problems would be greatest in Ashland, Colstrip, the new town, and Sheridan. Rosebud County would grow by the greatest percentage, Sheridan County by the greatest number of people.

Ashland would experience impacts comparable to Colstrip during construction of Colstrip units 1 and 2. Rapid population growth there would not be due to the proposed developments. Colstrip unit 5 would cause continued growth in Colstrip; the town would grow almost as large as Miles City is now. A bust cycle would likely follow after 1990, and would be more severe than with units 3 and 4 alone. The proposed developments would account for about 2,000 of the more than 8,000 people in Colstrip after 1986.

Sheridan would experience a period of major industrial growth due to construction of the Prairie Dog Creek generating plant, but impacts would be less severe than those experienced in, say, Rock Springs, Wyoming. The Sheridan urban area would grow very rapidly after 1984 and the population would be very much greater than for the other production levels. The proposed developments, however, would contribute negligibly to that population unless the new town were not built: then they would progressively contribute about 3,000 of the 25,000 people in and near Sheridan in 1990.

In Big Horn County, growth would be concentrated in the new town, which would grow almost 12 percent per year through the 1980's. About two-thirds of its population would be due to the proposed developments. Hardin would not be strongly impacted by the proposed and concurrent developments at the high production level: with all of them together, its growth would be slightly faster before 1984 than without them, slightly slower thereafter.

Forsyth would experience a second growth surge from 1984 to 1986, but at a much lower rate than Colstrip. Its growth after 1986 would be negligible. The proposed developments would account for about 1,000 of its 4,400 people after 1986.

Custer, Powder River, and Treasure Counties would be negligibly affected by the proposed developments, although Powder River and Custer Counties would grow faster than under the low and intermediate levels of coal production. Ashland would grow rapidly from projected mines along the Tongue River and on Otter Creek; it would reach the size of present-day Colstrip by 1988.

8. Economics

a. Taxation

1) Big Horn County

Fiscal conditions in Big Horn County would be fairly similar to those under the baseline production level. Mine-related construction, beginning in 1979, might create a short fiscal time lag for local governments. In 1980 more than 1,000 construction workers would be employed on mine-related projects in Big Horn County. But, gross-proceeds taxes would not be available to local governments until 1981, when the new mines began significant production. (See table VIII-12.)

2) Rosebud County

Fiscal conditions in Rosebud County would generally improve under the high production level: the greater level of energy development would contribute to a more stable economic atmosphere than under baseline or intermediate conditions. The sharp population increase due to Colstrip units 3 and 4 would not occur for unit 5. The construction of unit 5 would begin in 1984, as units 3 and 4 were being completed. Construction of unit 5 would thus tend to reduce fiscal management problems that would occur in the intermediate production level for Rosebud County (table VIII-13).

3) Sheridan County

The Prairie Dog Creek generating units would change fiscal conditions considerably in Sheridan County. County revenues and average school district revenues would increase significantly from 1985 to 1990 (table VIII-14), due to additional property and sales taxes generated by the economic activity from the Prairie Dog Creek units. Public-service expenditures would also increase during the Prairie Dog Creek construction period, but at a slower rate than revenue.

TABLE VIII-12.--Annual growth rates of revenues and spending, Big Horn County, Montana, high level

[Percent]

Year	County		School district	
	Revenue	Spending	Revenue	Spending
1978---	17.9	0.5	3.8	0.8
1979---	35.8	12.4	23.9	19.5
1980---	-18.0	4.3	7.7	4.3
1981---	36.0	.1	10.3	.1
1982---	27.0	1.5	11.2	2.4
1983---	9.4	7.6	5.2	2.3
1984---	6.7	.78	3.9	1.2
1985---	4.2	1.5	3.2	2.3
1986---	2.6	1.6	2.5	2.4
1987---	-.2	1.4	1.0	2.2
1988---	-.1	1.5	1.1	2.3
1989---	-.1	1.5	1.1	2.3
1990---	-.2	4.1	3.4	6.3

TABLE VIII-13.--Annual growth rates of revenues and spending, Rosebud County, Montana, high level

[Percent]

Year	County		School district	
	Revenue	Spending	Revenue	Spending
1978---	-19.0	0.7	-8.7	1.0
1979---	5.1	3.1	4.6	4.7
1980---	-1.2	11.8	17.3	18.6
1981---	-2.0	7.7	8.3	11.9
1982---	1.4	7.4	9.3	11.6
1983---	36.5	-0.5	7.8	-0.7
1984---	27.8	-1.3	6.5	-2.1
1985---	6.8	4.5	7.0	7.0
1986---	5.0	5.9	7.8	9.1
1987---	-1.6	-0.6	-1.2	-1.0
1988---	18.6	0.2	6.5	0.4
1989---	4.2	1.3	2.9	2.0
1990---	5.0	4.1	5.9	6.3

TABLE VIII-14.-Annual growth rates of revenues and spending, Sheridan County, Wyoming, high level

[Percent]

Year	County		School Districts	
	Revenue	Spending	Revenue	Spending
1978---	2.9	8.4	8.1	8.6
1979---	19.1	7.5	11.7	7.6
1980---	27.0	9.4	16.5	9.6
1981---	3.4	7.5	7.4	7.5
1982---	8.7	8.6	8.5	10.8
1983---	7.6	8.5	8.4	8.7
1984---	6.3	7.5	7.4	7.6
1985---	32.1	14.0	22.7	14.5
1986---	39.2	11.2	26.7	11.6
1987---	30.8	9.1	21.8	9.2
1988---	15.3	7.3	12.6	7.4
1989---	16.1	8.8	13.2	9.0
1990---	17.8	10.4	17.4	10.7

The new town would make local governments near Sheridan better off. The convenience of living near their jobs would attract many of the new miners and their families to the new town. If the new town did not exist, these people would most likely live in Sheridan, and the public expenditures associated with the residents of the new town would be transferred from Wyoming to Montana. However, these people would do most of their shopping in Sheridan, which is the nearest trade center. Thus, Wyoming would receive sales taxes from the new miners, and yet be relieved of providing most of their public-service needs.

4) Powder River County

The Moorhead Dam and the Otter Creek mine would change fiscal conditions in Powder River County. The proposed developments would not contribute to these impacts. Gross-proceeds taxes from the Otter Creek mine would increase county and average school district revenues when the mine began producing in 1986. Local governments would not be expected to experience a significant increase in public service costs, since most of the workers would probably live in Rosebud County.

On the other hand, local governments in Powder River would experience increasing costs associated with the Moorhead project construction force. Local governments would be responsible for providing public services for the newcomers; however, very little revenue would be generated from the project because it would be Federally owned and operated.

b. Cities

Impacted cities and towns in Montana under the high level would find it more difficult to finance public services. Greater energy development in the region would increase city populations, but mines are generally outside municipal tax boundaries, so gross-proceed taxes from the mines would not go diretly to municipal governments.

Sheridan would experience similar problems, but not to the same extent as towns in Montana, because Sheridan would receive sales-tax revenues generated by the additional economic activity associated with higher energy development.

c. Income

Mining and its derivatives, i.e. the railroad and generating units, would become the largest source of personal income in the Montana portion of the study area. There would not be any other significant differences in income or poverty levels compared to the intermediate level of production.

d. Reservations

Economic conditions on the Crow and Northern Cheyenne reservations would not differ substantially from projected (baseline) conditions. Approximately 40 Northern Cheyenne would be able to get temporary employment in the construction of Colstrip unit 5. Perhaps a few more (about another 36) might get jobs with the new mines located in the Tongue River corridor.

9. Community Services

Colstrip, Ashland, the new town, and Sheridan would have greater needs for community services under the high level. Of these communities, Ashland has the least experience dealing with growth and would probably have difficulty accomodating the relatively rapid influx of people associated with the Nance mine and other new mines in the area.

10. Land Use

The three proposed mines would use 1,160 of the 8,980 acres used for mining from 1978 to 1985 and 2,120 of the 18,080 acres used for mining from 1978 to 1990 (fig. VIII-2). Mine facilities would require about 4,900 acres for the lives of the mines.

Population growth due to the proposed developments would require about 110 of the 660 acres of new residential land by 1985 and 120 of the 850 acres by 1990 (new since 1978; all figures are approximate) (fig. VIII-2). Although most of the demand would be in the southern part of the region, some of it would occur in Colstrip, the Yellowstone valley, and the Hardin-Lodge Grass corridor.

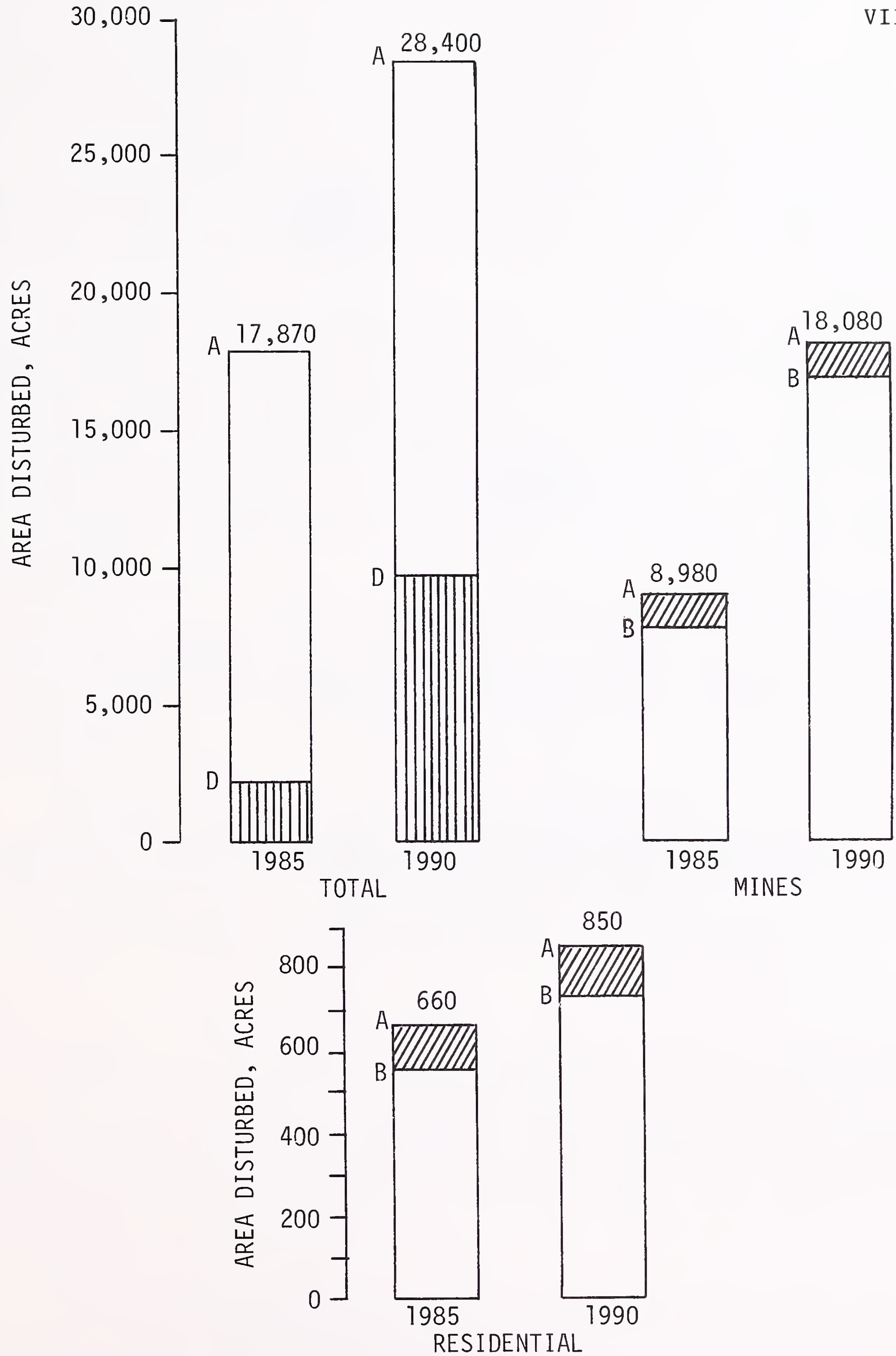


FIGURE VIII-2.--(A) Cumulative area disturbed by mining and derivative activities since 1978, high level of coal production. Diagonal rules (A-B) show disturbance due to proposed developments. Vertical rules (D) show mined area reclaimed since 1978.

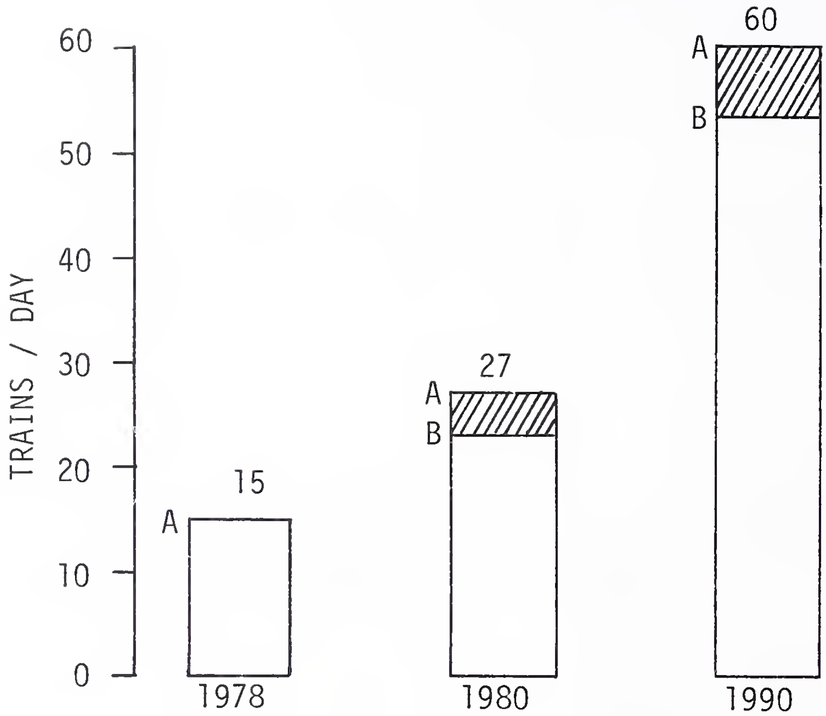


FIGURE VIII-3.--(A) Coal trains from the study area to external markets, high level of coal production (includes returning empty trains). Diagonal rules (A-B) show trains to and from proposed mines.

11. Transportation

In 1990, mines in the study area would export about 110 million tons of coal, requiring an average of 60 trains per day (including returning empty trains). The three proposed mines would account for an average of about 7 trains per day, if all of their coal were exported by rail. (See fig. VIII-3.)

A recently proposed coal-slurry line extending from the Decker-Sheridan area to Texas would have a capacity of 25 million tons per year. The pipeline is not included in any of the projected development levels. If such a line were in place by 1990 (which seems unlikely at the time of writing) and its full capacity were filled from this region, coal exports by rail from the region would amount to 88 million tons per year or 48 trains per day. If half the pipeline capacity were filled from the Decker-Sheridan area and the rest filled elsewhere, regional coal export by rail would amount to 100 million tons per year or about 55 trains per day.

Because of anticipated population growth, there would be about 10,000 more registered motor vehicles in the region in 1985 than in 1978 and about 13,000 more in 1990. Demand for commercial transportation services would increase, most likely in proportion to population increases.

12. Recreation

Recreation demands would increase negligibly over those for the intermediate production level, except in the Ashland area, where population increases from the Nance and other projected mines would cause increased littering, vandalism, and hunting pressure. There would be new demands for developed recreation facilities in Ashland.

13. Cultural Resources

Impacts beyond those of the intermediate production level cannot be determined because cultural resources have been only incompletely surveyed on projected mines. Projected mining on private coal along the Tongue River could disturb potentially high concentrations of prehistoric sites. Impacts there could be extensive because the Section 106 process of determining and protecting National Register sites would not be required.

14. Esthetics

The Nance mine and other projected mines along the Tongue River and on Otter Creek would introduce adverse esthetic impacts to an area now undisturbed by mining. The Nance mine would be very noticeable to people using the road along the Tongue River north of Birney.

D. ADMINISTRATIVE ALTERNATIVES AVAILABLE TO THE SECRETARY OF THE INTERIOR IN RELATION TO FEDERAL APPROVAL OF THE THREE PROPOSED COAL MINES ADDRESSED IN THIS STATEMENT

Each of the three mining and reclamation plans must be approved by both the Secretary of the Interior and the Commissioner of the Montana Department of State Lands. Various alternatives to direct approval of the proposed mines can be initiated by either the Secretary or the Commissioner when it is deemed necessary to minimize impacts of the proposed mining; however, modifications to the mining and reclamation plans must be approved by both the Secretary and the Commissioner. Because of differences between Federal and State regulatory and approving authorities, courses of action and alternatives imposed may be significantly different. The alternatives that apply to each of these mining proposals include those resulting from the administration of existing regulations of the Federal and State regulatory agencies. The options available to these agencies, as provided by existing legislation, and the resulting impacts of exercising these options are discussed below:

1. No Action

Pursuant to implied convenants of both the Federal mineral leasing laws and the existing lease agreements, the Secretary of the Interior must respond to legitimate applications to conduct operations on a valid Federal lease, provided all terms and conditions of the lease have been met. The Secretary's response may be approval as proposed, rejection on various legitimate grounds, or deferral of the decision based on proper grounds. "No action" on an applicant's proposed mining and reclamation plan would mean maintaining the status quo on the leasehold. The impacts of taking no action are discussed under the low production level in this chapter.

2. Defer Federal Action

In the event of noncompliance of an applicant's proposed mining and reclamation plan to provisions of the Surface Mining Control and Reclamation Act of 1977 (30 USC 1201), the Secretary must defer action on the proposed plan. For other proper causes, he may also defer the decision. Such causes could include, but are not limited to, the time required and the need for the following:

- Modification of the proposal to correct deficiencies unrelated to SMCRA or to reduce or avoid environmental impact.
- Acquisition of additional data to provide an improved basis for technical or environmental evaluation.
- Further evaluation of the proposal and/or alternatives.
- Development of an adequate system to monitor impacts for management and regulation.

The principal effect of deferring action would be a short-term delay in the imposition of all related impacts, both adverse and beneficial, of the three proposals discussed in this statement.

The mining and reclamation plans included in this statement were prepared prior to the promulgation of the initial regulations (30 CFR 700) required under Section 502 of the Surface Mining Control and Reclamation Act of 1977 (SMCRA).

The Office of Surface Mining (OSM), which was created by that act, has not reviewed the original plans for compliance. Therefore, these mining and reclamation plans may not reflect the requirements of the initial regulations. However, in this statement the applicable initial regulations are considered as a required Federal mitigating measure and are included in chapter I.

The original mining and reclamation plans for the Big Sky expansion and the Spring Creek mine were returned to the operators by the Montana Department of State Lands with a request that they be revised in accordance with the applicable regulations. In response to that request, the companies subsequently submitted preliminary modifications of the mine plans.

3. Prevent Development of the Lease

a. Reject the mining and reclamation plans

The Secretary may reject a proposed plan that does not meet the prescriptions of applicable law and regulations under his authority, including the potential for environmental impact that could be reduced or avoided by adoption of a significantly different course of action by the applicant. Except when a mine plan does not comply with existing regulations, the Secretary cannot under present circumstances reject the proposed plan to the extent that a de facto cancellation of a lease results unless he seeks and obtains additional authority from the Congress. Viability of this option is dependent upon timely legislative action; the option of rejecting a proposed plan pending legislation remains available.

If the Secretary were to reject a mining and reclamation plan, the lease would not be mined, and the resulting impacts would be deferred and potentially reduced or eliminated, dependent on the acceptance of a new proposal. The lease would continue in its present condition, subject to modification by natural processes and by the continuation of other existing activity and uses--and to further modification by the surface owner to meet other uses. However, the development of alternative sources of energy, such as other coal mines in the county, or a reduction of national energy consumption, could result. An applicant could correct the deficiencies in the plan and resubmit a modified mining and reclamation plan for approval. The result would be similar to that described in the alternative "Defer Federal Action."

b. Seek legislation to cancel the lease

The Secretary has very limited authority with respect to cancellation of an existing Federal coal lease. One such authority is prescribed in the lease terms entitled "Proceedings in Case of Default."

A second authority was mandated by provisions of section 6 of the Federal Coal Leasing Amendments Act of 1975 (P.L. 94-377) which was subsequently written into regulations as 43 CFR 3500.5. The authority relates to failure of the lessee to meet the requirements for diligent development of the lease as defined by the act.

The authority to cancel on other grounds would require congressional authorization for such action as well as for the requisite funds for compensation to the lessee. The Administration has not requested such legislation, and the Congress has not initiated such legislation related to the matters considered in this statement. The possibility of such actions is a matter for further consideration by the Administration and the Congress in the light of this environmental statement and other relevant nonenvironmental concerns.

To the extent that future coal production from these leases was curtailed or halted, alternative sources of energy would be required to meet anticipated needs and demands. The time required to replace the coal production potential could range from a few to several years. If these leases were cancelled through congressional authorization, all physical, biologic, and socioeconomic impacts stemming from the proposed mines would be avoided. Conversely, if development eventually were authorized, environmental impacts as discussed in chapter IV would occur, although impacts would be deferred in time and perhaps reduced because of changes in technology or requirements imposed at that time.

c. Exchange the existing leases

If the Secretary determines it to be in the public interest, he may initiate a proposal to the lessees for exchange of the existing Federal leases involved in this proposal for lease of other tracts of Federal coal or tracts of Federal sodium, phosphate, potash, or sulfur of comparable value, or for a grant of various future rights.

The Department of the Interior considers that the public interest would be so served if the Secretary finds that the benefits of production from these leases would not outweigh the adverse effects, or threat of damage of destruction to agricultural production potential, or scenic, biological, geologic, historic, or other public interest values from lease operations. In exercising his discretion to exchange mineral leasing values in the public interest, the Secretary shall consider, but is not limited to, consideration of these elements of the public interest: recreational use; archeological or historic values; threatened or endangered species; proximity of residential or urban areas; study for potential inclusion in the wilderness or wild and scenic rivers systems; and value for public highways, airports, and rights-of-way.

Should the Secretary initiate such a proposal, the lessees are under no obligation to enter into such negotiations and may refuse to consider it.

If such a proposal is made and is rejected by the lessees, or if negotiations are entered and not agreeably concluded by the parties, and if the three coal mining operations described in this statement are not otherwise prevented, such operations would eventually proceed and result in the impacts identified herein.

If an exchange proposal is made, accepted, and agreeably concluded for coal that is contiguous to or very near the existing lease, the proposed plans would have to be revised, resubmitted, and assessed. If the new plans encompassed the same methodology to be used in coal development, many of the impacts described herein would likely be very similar to those resulting from the new proposals, with a relatively short-term delay (several years) in their initiation. If a wholly different methodology is proposed for development of the replacement lease (e.g., underground versus surface mining), it could be substantially different from those described in this statement, and cannot be forecast at this time.

Presumably the unacceptable impacts or effects prompting the exchange would be avoided or substantially reduced, in development of the replacement lease, and found to be in the public interest. The existing lease would be relinquished, would not be mined, and would continue in its present condition.

If an agreeable exchange were made for coal located elsewhere, or for a different mineral commodity located elsewhere, the relinquished leases would continue in their present condition, subject to modification by natural processes, by the continuation of other existing uses and activity, and to further modification by the surface owners to meet other uses. Potentially, the coal reserves relinquished would be withdrawn from development and this source of energy foregone. Direct financial benefits to the public may change in an exchange of leases.

The impact of exploration and development of replacement leases under these circumstances will be translocated in space and time. They will relate to time and location, physical environment at the new sites, mineral commodity involved, development technology proposed and approved, and other factors, none of which can be quantified or evaluated until the replacement leases are identified. The environmental impact of potential development of the replacement lease rights to be granted would be evaluated and considered in the exchange process, and while they may be greater or less than those described in this statement, they must be ultimately judged by the Secretary to be more environmentally acceptable than development of the relinquished leases, and to be in the public interest. Costs to the Department in identifying and evaluating one or more replacement tracts to be offered in the exchange could be substantial, and very likely be significantly more than the lessee's costs in establishing the fair market value of the tract to be relinquished.

d. Suspend operations

Full development of the existing leases could be delayed by suspension of operations. If such action were taken, there would be no additional incremental environmental impact on the areas, and they would continue in their present condition, subject to further modification by natural processes, the continuation of existing mining activity, and such future uses of the surface as the owners may decide.

The authority of the Secretary of the Interior to suspend operations on existing leases has already been utilized on other Federal leases. Suspension of operations of these existing leases, for reasonable periods, with proper grounds, could be imposed. The Secretary cannot, under present circumstances, suspend operations to the extent that a de facto cancellation of a lease results unless he seeks and obtains additional authority from Congress. Viability of this option is dependent upon timely legislative action; the option of suspending operations pending legislation remains available. Impacts of this alternative would be similar to those described under "Cancel the Lease."

e. Federal reacquisition of leased rights

The outstanding leasehold interests could be acquired by the Secretary. The ability to acquire the leasehold interests is not granted by the existing relevant statutes and would require Congressional authorization for such action as well as for the requisite funds for compensation of the lessees. To date, the Administration has not requested such action, and the Congress has not initiated or considered such legislation; the possibility thereof is thus conjectural at best. The major effects of such Congressional authorization would be similar to those of cancellation of the leases as previously discussed.

4. Restrict Development on the Leases

The subject leases convey the right to develop, produce, and market the Federal coal resource thereon if all other terms and conditions have been met by the lessee. In general, the Secretary does not possess the authority to arbitrarily restrict development either as to location or rate. Various measures that may tend to restrict development may be taken by the Secretary at any time in the interest of conservation of resources or in the protection of various specific environmental values in accordance with existing laws and regulations; for example, the National Historic Preservation Act of 1966, the Endangered Species Act of 1973, etc.

Thus, under present conditions, a general effort to restrict or regulate development of the existing leases for reasons other than failure to comply with existing laws and regulations would constitute a selective application of the "prevent development" alternative already discussed; that decision, as it related to impacts, possible litigation, and the need for authorizing legislation, would be relevant in this instance.

In addition, application of this alternative might not permit maximum recovery of the coal resources and would thus be contrary to principles of conservation embodied in the legislation which authorizes the leasing of these lands for the purposes described. It is entirely possible that such selective mining would leave isolated blocks of coal that might never be recovered owing to the high costs of mining such remnant areas at a later date.

5. Require Modification of the Plans to Improve Them Technically and Reduce Anticipated Impacts of the Operation

A number of the impacts identified and described in chapter IV of this statement could be more fully mitigated by the application of one or more of the technical alternatives described more fully in part F below. Among the more obvious options to be considered are the kinds of technical modifications that may be covered by requirements of the Surface Mining Control and Reclamation Act when fully implemented as 30 CFR 700 et seq. Examples of these would be:

- Change in the configuration of the proposed mine areas in order to avoid sites or features of special environmental value, such as alluvial valley floors.

- Modification of dust control technology at the minesites and loadout facilities, and the control of dust loss from unit-trains.

- Modification of proposed postmining topography.

- Modification of proposed reclamation practices applied to overburden, topsoil, revegetation, and protection of the reclaimed surface.

- Modification of proposed wildlife management practices.

Such modifications could include any that might be imposed by the State of Montana in its approval process. Under the joint agreement (30 CFR 211), the State advises the Secretary of its decision, and the Secretary subsequently renders his decision on the State-approved plan (See chapter VIII, Administrative alternatives available to the Montana Department of State Lands.) In addition, special conditions could be added to the approved plans in relation to the secondary effects of mining. Such conditions must be reasonable and, if unacceptable to the lessee, could result in the lessees not developing the lease areas with the resultant impacts previously discussed in chapter VIII under the subsection entitled, "Reject the Mining and Reclamation Plan."

6. Allow Development of Selected Areas Now Under Lease

This alternative would permit only selective exploration and development of the existing leaseholds, based on anticipated adverse environmental consequences. The decisionmaker has the authority and responsibility to evaluate the coal resources and impacts of mining on this lease prior

to acting on the proposal. Exploration and development could be allowed only on the leaseholds, or portions thereof, that would have the lowest anticipated adverse environmental consequences. Weighing the tradeoffs of mining or precluding mining on selected tracts is part of the evaluation and decision process. Adoption of this alternative would reduce adverse effects by reducing the area in which the impacting activities could take place.

The alternative of allowing the development of only selected areas already under lease constitutes a selective application of the alternative of preventing further development of the existing leases described above. Without a showing lease-by-lease or plan-by-plan of the likelihood of wholly unacceptable environmental impacts that could not be reduced to an acceptable level, the Secretary does not possess the authority to otherwise constrain development of the leaseholds if all other requirements of the lease have been met. In addition, application of this alternative would be contrary to principles of conservation embodied in the legislation which authorizes the leasing of these lands for the purposes described. It is entirely possible that such selective mining would leave isolated blocks of coal that might never be recovered owing to the high costs of mining such remnant areas at a later date.

E. ADMINISTRATIVE ALTERNATIVES AVAILABLE TO STATE AGENCIES

1. Department of State Lands

The authority for State action regarding mining and reclamation rests with three laws:

- Montana Strip and Underground Mine Reclamation Act
- Montana Strip Mine Siting Act
- Montana Strip-Mined Coal Conservation Act

The State does not have an equivalent to the Federal "no action" alternative. If, in fact, no action were taken by the Department within 240 days after receipt of a complete application for a mining and reclamation permit, the permit would be statutorily approved, by default.

The State also does not have a formal administrative alternative to "defer action" following the receipt of a completed application for a mine and reclamation permit. However, the State may deem an application incomplete due to failure of the mine and reclamation plan to meet State requirements, leading to a postponement of the action, which has the effect of deferral.

Other than the decisions to approve or disapprove a permit, only two viable alternatives are open to the State: (1) approval of the permit with modification; and (2) selective denial of the permit to mine in a specified area that includes lands having special, exceptional, critical

or unique characteristics, or where mining would affect the use, enjoyment, or fundamental character of neighboring land having the above special characteristics. Either or both of these alternatives, which could be legally invoked after the permit application was deemed complete, would generally be exercised by the Department during its review of the application, thereby making modification and/or selective denial prerequisite to the acceptance of a completed application.

Impacts that would result from rejection of the three mine permit applications would be the same as those discussed under the Federal administrative alternative of preventing development of the existing leases.

2. Department of Health and Environmental Sciences

The Montana Clean Air Act is the law under which the Department of Health and Environmental Sciences would exercise its authority to take action on the applications for a permit to construct and operate coal-handling facilities. Such action would pertain to the designs for constructing coal-crushing, storage, and loadout structures, and to the operation of coal-handling facilities after construction, in order to ensure that the best possible control technology would be applied toward preventing and abating air pollution.

Three administrative alternatives open to the Department are disapproval, approval, or approval after acceptable modification of the construction and/or operating designs.

Decisions of the Department of Health and Environmental Sciences are not contingent on those of the Department of State Lands, with the result that disapproval by either Agency would cause rejection of the entire project. The impacts due to disapproval of a permit for coal-handling facilities would therefore be the same as those from rejection of the mine and reclamation permit. Impacts due to approval of the coal-handling facilities are those analyzed in chapter IV. Impacts that would result from modification of the designs for construction and/or operation of coal-handling facilities are discussed under Technical Alternatives.

3. Department of Natural Resources and Conservation

Under the Montana Act, the Montana Department of Natural Resources and Conservation has authority to take action on the permit applications for railroad access corridors.

F. TECHNICAL ALTERNATIVES

The Commissioner of State Lands or the Secretary of the Interior could impose the following stipulations on the mine plans.

1. Geology, Soils, and Vegetation

- Require that the upstream portions of small watersheds outside the permit area, which may be disturbed by erosion from mining, be bonded at the associated level of disturbance.

  If gullying should develop in the restored ephemeral drainages crossing a reclaimed mine surface, it could spread upstream into the unmined portions of the watershed. Bonding would hold the mining company accountable for severe erosion problems if they should spread beyond the permit area.

- Initiate long-term multidisciplinary monitoring and management for reclaimed minelands.

  Erosion processes in a semiarid climate are intermittent, and geomorphic processes would take long periods of time to restore a natural level of landscape stability. Initially, mined lands would be more susceptible than native range to erosion. With time, as infiltration characteristics were restored and soil structure developed, erodibility of the mined surface would return to natural levels. This process, however, may take decades to centuries. During this time severe erosion problems (rilling and gullying) could develop quickly.

  Monitoring would detect such problems early, making it possible to prevent unchecked erosion from spreading across the reclamation surface and into adjacent unmined areas. Monitoring reclaimed areas would also make it possible to identify the cause of local reclamation failures so as to prevent recurrences.

  In addition, since the oldest mining in the area is only 50 years old, and reclamation efforts began in 1973, exact long-term effects are unidentified. The success of reclamation is unknown over the long term.

  Continued monitoring and collection of data would provide information for the improvement of future reclamation programs. Long-term monitoring would also provide information on the rates and direction of plant community development and succession, plant tissue composition, soil development, spoil weathering, geomorphic readjustment, weather patterns, and the interaction of the processes.

  The monitoring program should fully characterize spoil and soil materials at time of deposition, record treatments, and continuously record meteorological and soil conditions. It should also monitor soil characteristics relating to water infiltration, permeability and storage, soil aeration, and root growth. For the semiarid West, where grazing and wildlife habitat concurrently dominate land uses, the goals of such a monitoring project would be to isolate and quantify the factors that produce a diverse and stable landscape

capable of supporting premining land uses without special management, within a relatively short period of time.

Some of the benefits of long term monitoring and research would accrue to other concurrent and future mining operations. Because of this, the cost of establishing and maintaining such studies should be borne at least in part by public agencies, possibly coordinated with research projects ultimately developed by the Title VIII Coal Research Laboratories authorized by SMCRA. The cost could be spread further by concentrating the studies on carefully selected representative mines.

- Collect more baseline information on both physical and social conditions in the Northern Powder River Basin.

  Available data only partially describe the region. Missing data must be inferred from data on similar regions or from the application of general principles. Both approaches are subject to error. Little is known about the mineralogy of the Fort Union formation, and nothing specific about erosion rates or sediment yields.

  The Secretary or the Commissioner could initiate or fund a comparative longitudinal study of social change in the northern Powder River basin, either through an existing agency or by providing funds to an independent research group or university. The study would show how the mining development projected in this EIS affects the social structure of the area over time--information which is not now available for the study area. The study would continue for perhaps a decade or more, but would yield useful information on the effect of mining development on people's well-being after only a few years. This information could then be used to channel impact assistance money to the locations and institutions where it is most needed.

- Maintain the ambient sediment loads of mine waters released to natural drainages.

  Under the present mine plans and legal requirements (chapter III), the waters released to natural drainages would be sediment-deficient compared to natural streamflow.

  In perennial streams, this alternative would decrease the likelihood that the stream would downcut into its channel, thereby lowering the adjacent alluvial water table and reducing the availability of ground water to flood-plain vegetation.

  In ephemeral streams, the alternative would prevent localized erosion, which could initiate gullying throughout the upstream drainage network. Such erosion would lower the alluvial water table throughout the upstream watershed.

- Require mining companies and the Office of Surface Mining to prepare soils maps, and develop a system of capability and range site classification for both current mines and orphan spoils.

  Soil maps and capability classification, in conjunction with monitoring programs and land use trials, would allow land managers full information in determining the highest use, and avoid inadvertent overuse, which would have long-term effects.

2. Wildlife

- Require the mining company to plant trees and shrubs by the most current and successful technology, in densities and distribution similar to those existing before mining. They should be planted on reclaimed areas where grass and forb seedings have been established, especially in disturbed drainages. This stipulation would benefit diverse wildlife species, especially those requiring ponderosa pine and shrub habitats. (See Wildlife, chapter IV.)

- The Commissioner could approve alternate reclamation plans to permit reestablishment of needed habitats such as ponds or segments of unreduced highwalls.

- Require standard antelope fences (Type I-BLM Manual 1737) at all the proposed mines. This would reduce losses of antelope, especially at the Spring Creek mine.

3. Economics

The Secretary or the Commissioner could formally suggest that the mining companies set up training programs in the local area to qualify people for jobs at the mines. It is not within their authority to require such programs as a condition of a mining permit. The training programs would necessarily be open to any qualified person, but they would provide opportunities for local residents to better compete for jobs at the mines.

A training program could reduce the numbers of newcomers to the area, thereby reducing unemployment, strains on community services, and social impacts due to conflicts between newcomers and long-time residents. At the same time, it could raise per-capita income, especially in Big Horn and Rosebud Counties, but also in Sheridan County, Wyoming.

CHAPTER IX

CONSULTATION AND COORDINATION WITH OTHERS

A. PREPARATION OF THE DOCUMENT

Instructions to prepare this regional environmental statement were issued to the Geological Survey and the Bureau of Land Management by the Secretary of the Interior on April 29, 1976, designating the USGS lead agency. Because of some duplicate or closely related actions pending before Federal and State agencies, and because of the similar requirements of the National and Montana Environmental Policy Acts, the State of Montana joined with the Federal task force in August 1976, in the preparation of this, as well as concurrent site-specific environmental statements. The State task force personnel were under the administrative supervision of a State team leader and the Commissioner of the Department of State Lands. Task Force offices were established in Billings, Montana (P. O. Box 1135, 59101) and Helena, Montana (Room 221, Power Block Bldg., 59601).

Information was gathered and analyzed by the joint Federal and State task force. Archeological reconnaissance of the proposed minesites was performed under contract by Anthropologos Research International, Inc. of Livingston, Montana (report on file at the Task Force office in Billings) to supplement the data provided in mining applications. Major inputs were provided by the Montana Departments of Natural Resources and Conservation; Community Affairs; Highways; Health and Environmental Sciences; and Fish and Game; Montana State University, Department of Agricultural Economics and Economics (Coal Town II computer model projections) and University of Montana, Department of Environmental Studies (climate and air quality computer model analyses). Input was also provided by the Sheridan County, Wyoming, Board of Commissioners, the Sheridan Area Planning Agency (SAPA), and the Sheridan County Planning Commission. A report on social conditions and projected social impacts in Sheridan County that would result from the Spring Creek mine was prepared for the task force under contract by the Center for Urban and Regional Analysis, University of Wyoming. Reports on demographic conditions and community services in the study area were provided under contract by the University of Montana.

Other Federal and State agencies providing consultation to the preparation of this draft environmental statement include the following:

Federal agencies	State agencies
Bureau of Mines	Montana Bureau of Mines and Geology
U.S. Forest Service	Montana Energy Advisory Council
U.S. Fish and Wildlife Service	Montana Department of Community Affairs
U.S. Environmental Protection Agency	Montana Historical Society
Bureau of Indian Affairs	Wyoming Department of Administration
Bonneville Power Administration	Wyoming Department of Revenue and Taxation
Interstate Commerce Commission	Employment Security Commission of Wyoming
Office of Surface Mining	

Local agencies	Non-Government organizations
Powder River County Commissioners	Burlington Northern Railroad
Rosebud County Planning Director	Montana State University
Treasure County Commissioners	Old West Regional Commission
Public service departments, city	Northern Plains Resource Council
governments and schools of:	Northern Cheyenne Research Project
Broadus	Northern Energy Resources Co., Inc.
Colstrip	Pacific Power and Light Co.
Decker	Peabody Coal Company
Forsyth	Shell Oil Company
Hardin	MONTCO
Hysham	Montana Power Co.
Lame Deer	Decker Coal Co.
Miles City	Western Energy Co.
Rosebud	Westmoreland Resources, Inc.
	Cumin Associates
	Powder River Basin Resource Council
	Sheridan Chamber of Commerce
	ACTION for Eastern Montana
	Dist. VII Human Resource Council

B. COORDINATION IN THE REVIEW OF THE DRAFT ENVIRONMENTAL STATEMENT

In accordance with guidelines of the Council on Environmental Quality and the Montana Department of State Lands, copies of the draft statement will be made available to the public for their comments and suggestions.

A limited number of copies are available on request from the U.S. Geological Survey, Environmental Impact Analysis Program, Box 25046, Mail Stop 701, Federal Center, Denver, CO 80225; and over the counter only, from the U.S. Geological Survey Public Inquiries Office, Room 1012, Federal Building, 1961 Stout Street, Denver, CO 80202; and the Montana Department of State Lands, 1625 11th Ave., Helena, MT 59601.

Written comments on the draft statement will be accepted for a period of 45 days subsequent to filing with EPA and the Montana Environmental Quality Council. All substantive comments received will be considered in preparing the final environmental statement. Written comments should be addressed to Director, U.S. Geological Survey, 108 National Center, Reston, VA 22092.

Comments on the draft environmental statement are sought from industry, officials from all levels of government, environmental groups, and concerned citizens.

The draft environmental statement is available for public review at the following places:

- U.S. Geological Survey Public Inquiries Office, Room 1012, Federal Building, 1961 Stout Street, Denver, CO 80202
- U.S. Geological Survey Library, 1526 Cole Blvd., Golden, CO 80401
- U.S. Geological Survey Library, Room 4A100, USGS National Center, 1201 Sunrise Valley Drive, Reston, VA 22092
- Montana Department of State Lands, 1625 11th Ave., Helena, MT 59601
- Bureau of Land Management (West of Miles City), P. O. Box 940, Miles City, MT 59301
- Parmley Billings Public Library, 510 North Broadway, Billings, MT 59103
- Sheridan County Fulmer Public Library, 320 North Brooks, Sheridan, WY 82801
- Big Horn County Public Library, 419 North Custer Ave., Hardin, MT 59034
- The Montana State Library, State of Montana, 930 East Lyndale, Helena, MT 59601
- The Rosebud County Library, 201 North 9th Ave., Forsyth, MT 59327

CHAPTER X

REFERENCES

Abshire, N. L., Derr, V. E., McNice, G. T., Pueschel, R. F., and VanValin, C. C., 1977, Integrated aerosol characterization monitoring, Colstrip, Montana: The bioenvironmental impact of a coal-fired power plant, Third Interim Report, Colstrip, Montana, December 1977, p. 295-324.

Agee, E. M., 1971, An artificially induced local snowfall: American Meteorological Society Bulletin, v. 52, p. 557-560.

Algermissen, S. T., and Perkins, D. M., 1977, Earthquake-hazard map of the United States: U.S. Geological Survey, Earthquake Information Bulletin, v. 9, no. 1, p. 21.

Arnold, F. B., and Dollhopf, D. J., 1977, Soil water and solute movement in Montana strip mine spoils, v. 1 of a continuing study: Bozeman, Montana State University, Montana Agricultural Experiment Station, Research Report 106, 128 p.

ARS-NDAES, 1977, Research on reclamation of strip-mined lands in the Northern Great Plains, Progress Report, 26 p.

Auclair, D., 1976, Effects of dust on photosynthesis; I, Effects of cement and coal dust on photosynthesis of spruce: Annales des Sciences Forestieres, v. 33, p. 247-256.

Beetle, A. A., 1960, A study of sagebrush; the section of tridentatae of Artemisia: University of Wyoming Agricultural Experiment Station, Bulletin 368, 83 p.

Beckes, M. R., 1974, Preliminary archeological survey of Custer National Forest, southeastern Montana: Missoula, University of Montana.

Bennett, J. H., and Hill, A. C., 1974, Acute inhibition of apparent photosynthesis by phytotoxic air pollutants: American Chemical Society Symposium Series no. 3, p. 115-127.

Berg, R. B., Lawson, D. C., Jones, F. P., and Smith, R. I., 1970, Progress report on clays and shales of Montana, 1968-1969: Montana Bureau of Mines and Geology Bulletin 80, 27 p.

______ 1973, Progress report on clays and shales of Montana: Montana Bureau of Mines and Geology Bulletin 89, 18 p.

Biscoe, P. V., Unsworth, M. H., and Pinckney, H. R., 1973, The effects of low concentrations of sulfur dioxide on stomatal behavior in Vicia faba: New Phytologist, v. 72, p. 1299-1306.

Bolt, G. H., and Bruggenwert, M. G. M., 1976, Soil chemistry; A, basic elements: New York, Elsevier Publishing Co., 281 p.

Boscak, Vladimir, and Tandon, J. S., 1974, Development of chemical for suppression of coal dust dispersion from storage piles: Presented at the Fourth Annual Environmental Engineering and Science Conference, University of Louisville, Louisville, Kentucky, March 4-5, 1974, 14 p.

Bown, Thomas, and McGrew, P. O., 1977, Paleontological resources investigations of the Spring Creek area, p. 93-97, in Archeology, history, and paleontology, Spring Creek project environmental baseline studies: Northern Energy Resources Company, application for Spring Creek mining and reclamation permit.

Brandt, C. J., and Rhoades, R. W., 1972, Effects of limestone dust accumulation on composition of a forest community: Environmental Pollution, v. 3, p. 217-225.

______1973, Effects of limestone dust accumulation on lateral growth of forest trees: Environmental Pollution, v. 4, p. 207-213.

Bromenshenk, J. J., 1978, Honeybees and other insects as indicators of pollution impact from the Colstrip power plants, in The bioenvironmental impact of a coal-fired power plant: Environmental Studies Laboratory, University of Montana, Fourth Interim Report, December 1978, p. 75-99.

Brown, Andrew, Culbertson, W. C., Dunhan, R. J., Kepferle, R. C., and May, R. R., 1954, Strippable coal in Custer and Powder River Counties, Montana: U.S. Geological Survey Bulletin 995-E, p. 151-199.

Bryson, R. A., 1972, Climate modification by air pollution: Institute for Environmental Studies, University of Wisconsin, Report No. 1, p. 132-177.

Buckman, H. O., and Brady, N. C., 1972, The nature and properties of soils: New York, The Macmillan Co., 653 p.

Bury, R. L., Wendling, R. C., and McCool, S. F., 1976, Off-road recreation vehicles - A research summary, 1969-1975: Texas Agricultural Experiment Station Report MP-1277, 84 p.

Centaur Management, 1978, Lower Yellowstone area socio-economic analysis: Open-file report prepared for Montana State Office, U.S. Bureau of Land Management, 350 p.

Chaiken, R. F., Cook, E. B., and Ruhe, R. C., 1974, Toxic fumes from explosives, ammonium nitrate-fuel oil mixtures: Pittsburg, Pennsylvania, Pittsburg Mining and Safety Research Center, U.S. Bureau of Mines, Report on Investigations 7867, 24 p.

Coffey, Marilyn, 1978, Dust storms; with biographical sketch: Natural History, v. 86, no. 4, p. 72-83.

Constantinidou, H., Koslowski, T. T., and Jensen, K., 1976, Effects of sulfur dioxide on Pinus resinosa seedlings in the cotyledon stage: Journal of Environmental Quality, v. 5, p. 141-144.

Dale, E. E., 1960, The range cattle industry--ranching on the Great Plains from 1865 to 1925: Norman, University of Oklahoma Press.

Darley, E. F., 1966, Studies on the effect of cement-kiln dust on vegetation: Journal of Air Pollution Control Association, v. 16, p. 145-150.

Davis, C. M., 1976, A preliminary archeological reconnaissance survey, Bureau of Land Management, southeastern Montana: Missoula, University of Montana.

Dendy, F. E., and Champion, W. A., 1973, Summary of reservoir deposition surveys made in the United States through 1970: U.S. Agricultural Research Service, Miscellaneous Publications no. 1266, 82 p.

Dennison, R., Caldwell, B., Bormann, B., Eldred, L., Swanberg, C., and Anderson, S., 1976, The effects of acid rain on nitrogen fixation in western Washington coniferous forests, in Proceedings of the First International Symposium on Acid Precipitation and the Forest Ecosystem, L. S. Dochinger and T. A. Siliga, eds.: p. 933-949.

DePuit, E. J., Coenenberg, J. G., and Willmuth, W. H., 1978, Research on revegetation of surface mined lands at Colstrip, Montana: Bozeman, Montana State University, Montana Agricultural Experiment Station Program Report, 1975-77, 165 p.

Dochinger, L. S., and Seliga, T. A., eds., 1976, Proceedings of the First International Symposium on Acid Precipitation and the Forest Ecosystem, May 12-13, 1976, Columbus, Ohio: U.S. Forest Service.

Dollhopf, D. J., Hall, W. D., Schafer, W. M., DePuit, E. J., and Hodder, R. L., 1978, Selective placement of coal strip mine overburden in Montana: Bozeman, Montana State University, Montana Agricultural Experiment Station Research Report 128, 109 p.

Dollhopf, D. J., Goering, J. D., Levine, C. J., Bauman, B. J., Hedberg, D. W., and Hodder, R. L., 1978, Selective placement of coal strip-mine overburden in Montana; III, spoil mixing phenomena: Bozeman, Montana State University, Agricultural Experiment Station Research Report 135, 68 p.

Dunrud, R. C., and Osterwald, F. W., 1978, Effects of coal mine subsidence in the western Powder River Basin, Wyoming: U.S. Geological Survey Open-File Report 78-473, 71 p.

Ebens, R. J., and McNeal, J. M., 1977, Geochemistry of Fort Union shale and sandstone in outcrop in the Northern Great Plains coal province; in Geochemical Survey of the Western Energy Regions: U.S. Geological Survey Open-File Report 77-872, p. 185-197.

Ecological Consulting Service (ECON), 1976a, Annual small mammal and vegetation report: Peabody Coal Company, Big Sky mine, Progress Report, Project no. 131-83-A, 45 p., appendixes.

______1976b, Report on the annual wildlife monitoring studies for 1976 and the habitat diversity and utilization analysis for the period 1973-1976: Peabody Coal Company, Big Sky mine, Project no. 130-85-A, 68 p., appendixes.

EG & G Environmental Consultants, 1976, Summary report, CIRL Air Monitoring Program, October 2, 1975, to October 2, 1976: Prepared for Shell Oil Company Mining Ventures, December 1976.

Elliot, M. A., and Davis, R. F., 1950, Composition of diesel exhaust gas: J. A. E. Quarterly Transactions, v. 4, p. 330-346.

Ellison, Lincoln, and Woolfolk, E. J., 1937, Effects of drought on vegetation near Miles City, Montana: Ecology, v. 18, p. 329-336.

Employment Security Commission of Wyoming, 1971-78, Wyoming labor force trends: Cheyenne, Wyoming, v. 8-15, no. 1.

______1978, Wyoming labor force trends: Cheyenne, Wyoming, v. 15, no. 9, p. 2, 12.

EVST Laboratory, 1977, Determination of the acidity of precipitation samples collected at sites in the vicinity of Colstrip I and II: EVST Report, 6 p.

______1978, Colstrip Units 3 and 4: Emissions, vegetation and animal impacts, and possible fumigation episodes: Working paper prepared for Texas Instruments.

Erdman, J. A., Eben, R. J., and Case, A. A., 1978, Molybdenosis--A potential problem in ruminants grazing on coal mine spoils: Journal of Range Management, v. 31, no. 1, p. 34-36.

Eriksson, J., Hakansson, I., and Danfors, B., 1974, The effect of soil compaction on soil structure and crop yields: (Translated in 1975 from Swedish): Swedish Institute of Agricultural Engineering Bulletin 354, 101 p.

Fenneman, N. M., 1931, Physiography of Western United States: New York, McGraw-Hill Book Co., 534 p.

Fitzsimmons, S. J., Stuart, L. I., Wolff, P. C., 1977, Social assessment manual--A guide to preparation of the social well-being account for planning water resource projects: Boulder, Colorado, Westview Press, 289 p.

Fredlund, D. E., 1972, Archeological survey, Western Energy Company lands, Rosebud County, Montana: Missoula, Montana, University of Montana, statewide survey.

Gee, G. W., Bauer, Armand, and Decker, R. S., 1978, Physical analyses of overburden materials and mine land soils, in Schaller, F. W., and Sutton, Paul, eds., Reclamation of drastically disturbed lands: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin, p. 665-685.

Gelhaus, J. W., 1976, An air quality assessment of Colstrip, Montana, prior to development of coal-fired power plants: Montana Department of Health and Environmental Sciences, Air Quality Bureau, 90 p.

Gilbert, O. L., 1976, An alkaline dust effect on epiphytic lichens: Lichenologist, v. 8, p. 173-178.

Gilley, J. E., Gee, G. W., Willis, W. O., and Young, R. A., 1976, Water infiltration at surface mined sites in western North Dakota: North Dakota Farm Research, v. 34, p. 34-34.

Gilmore, John, 1976, Boomtowns may hinder energy resources development: Science, v. 191, p. 535-540.

Gold, R. L., 1974a, A comparative case study of the impact of coal development on the way of life of people in the coal areas of eastern Montana and northeastern Wyoming: Missoula, Final Report, Institute for Social Research, University of Montana (for Northern Great Plains Resource Program), 185 p.

______1974b, A social impact study of Colstrip generating plants Nos. 3 and 4--Summary of interview data: Missoula Institute for Social Research, University of Montana (for Montana Department of Natural Resources and Conservation and Montana State Social and Rehabilitation Services), 166 p.

______1975, A study of social impact of coal development in the Decker-Birney-Ashland area: Missoula, Final Report Institute for Social Research, University of Montana (for Montana Energy Advisory Council), 76 p.

Gordon, C. C., and Tourangeau, P. C., 1975. Conifer tree damage in the vicinity of large stationary sources of phytotoxic gases--Mount Storm, West Virginia and other areas of the U.S.: Air Pollution Control Association Paper No. 75-21.1, 38 p.

Gordon, C. C., Tourangeau, P. C., and Rice, P. M., 1978, Foliar pathologies of ponderosa pine near Colstrip, in The bioenvironmental impact of a coal-fired power plant: Environmental Studies Laboratory, University of Montana, Missoula, Fourth Interim Report, December 1978, p. 1-74.

Gregg, M., 1977, Archeological survey of the Pearl area, prepared for Shell Oil Company by the Division of Archeology and Cultural Resources, Montana Tech Alumni Foundation, Butte, Montana.

Grim, E. C., and Hill, R. D, 1974, Environmental Protection in Surface Mining of Coal, Office of Research and Development, Cincinnati, Ohio, U.S. EPA Program Element No. 1BB040, 277 p.

Guarnaschelli, Claudia, 1977, In-transit control of coal dust from unit trains: Environmental Protection Service, Fisheries and Environment Canada, Report No. EPS 4-PR-77-1, 54 p.

Guderian, R., 1977, Air pollution; phytotoxicity of acid gases and its significance: New York, Springer Verlag (C. J. Brandt, trans.), 127 p.

Haberman, T. W., 1973, 1972 archaeological survey in the Decker/Birney area of Big Horn County, southeastern Montana: A Western Interstate Commission for Higher Education Project, Boulder, Colorado; sponsored by the Bureau of Land Management, Billings, Montana, 105 p.

Hadley, R. F., and Schumm, S. A., 1961, Sediment sources and drainage basin characteristics in upper Cheyenne River basin: U.S. Geological Survey Water-Supply Paper 1531-B, p. 137-196.

Haines, Francis, 1971, Horses in America: New York, Thomas Y. Crowell Co.

Hinkley, T. K., and Ebens, R. J., 1976, Mineralogy of fine-grained rocks in the Fort Union Formation, in Geochemical Survey of the Western Energy Regions, Third Annual Progress Report: U.S. Geological Survey Open-File Report 76-729, p. 10-13.

______1977, Geochemistry of fine-grained rocks in cores of the Fort Union Formation, Northern Great Plains, in Geochemical Survey of the Western Energy Regions, Fourth Annual Progress Report: U.S. Geological Survey Open-File Report 77-872, p. 169-172.

Hinkley, T. K., Ebens, R. J., and Boerngen, J. G., 1978, Overburden chemistry and mineralogy at Hanging Woman Creek, Big Horn County, Montana, and recommendations for sampling at similar sites: U.S. Geological Survey Open-File Report 78-393, 59 p.

Hitchcock, C. L., Cronquist, A., Ownby, M., and Thompson, J. W., 1961, Vascular plants of the Pacific Northwest: Seattle, University of Washington Press.

Hobbes, P. V., Harrison, H., and Robinson, E., 1974, Atmospheric effects of pollutants: Science, v. 184, p. 909-915.

Hodson, W. G., Pearl, R. H., and Druse, S. A., 1973, Water resources of the Powder River Basin and adjacent areas, northeastern Wyoming: U.S. Geological Survey, Hydrologic Investigations Atlas HA-465.

Holzworth, G. C., 1972, Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States: U.S. EPA, January 1972, Office of Air Programs, 118 p.

Hutcheson, M. R., and Hall, F. P., Jr., 1974, Sulfate washout from a coal fired power plant plume: Atmospheric Environment, v. 8, p. 23-28.

Jenkins, D. A., and Davies, R. I., 1966, Trace element content of organic accumulations: Nature, v. 210, p. 1296-1297.

Jobes, P. C., and Parsons, M. G., 1975, Satisfaction, coal development and land-use planning--A report of attitudes held by residents of the Decker-Birney study area: Bozeman, Montana State University (submitted to the Montana Energy Advisory Council), 287 p.

Johnson, M. C., and White, R. V., 1975, Colstrip, Montana; the fiscal effects of recent coal development and an evaluation of the community's ability to handle further expansion: Unpublished report for the Department of Interior, Office of Mineral Policy Development, 76 p.

Klingebiel, A. A., and Montgomery, P. H., 1961, Land capability classification: U.S. Department of Agriculture, Agricultural Handbook 210, 21 p.

Kranzel, C. F., and McDonald, F. H., 1971, Social forces in rural communities of sparsely-populated areas. Montana State University, Agricultural Experiment Station, Bulletin 647, 17 p.

Larson, T. A., 1966, History of Wyoming: Lincoln, University of Nebraska Press.

LASA, 1978, Final report of data and conclusions for aerosol measurements model, October 3-6, 1978, at Western Energy mines, Colstrip, Montana: October 16, 1978, 7 p.

Lewis, B. D., and Roberts, R. S., 1978, Geology and water-yielding characteristics of rocks of the northern Powder River basin, southeastern Montana: U.S. Geological Survey, Miscellaneous Investigations Series, Map I-847-D.

Li, Ta-Yung, and Landsburg, H. E., 1978, Rainwater pH close to a major power plant: Atmospheric Environment, v. 9, p. 81-88.

Liang, C. N., and Tabatabai, M. A., 1978, Effects of trace elements on nitrification in soils: Journal of Environmental Quality, v. 7, p. 291-293.

Lomasson, Thomas, 1947, Influence of rainfall on the prosperity of eastern Montana, 1878 to 1946, <u>in</u> Developments in range management: Missoula, Montana, U.S. Forest Service, Region I, no. 7, April 1947, 1 p.

Lowie, Robert, 1954, Indians of the Plains: New York, McGraw-Hill.

Lusby, G. C., and Toy, T. J., 1976, An evaluation of surface-mine spoils area restoration in Wyoming using rainfall simulation: Earth Surface Processes, v. 1, p. 375-386.

Magill, E. A., Hubbard, C. R., and Stinson, D. L., 1967, Mineral resources and their potential on Indian lands, Northern Cheyenne Reservation, Big Horn and Rosebud Counties, Montana: U.S. Bureau of Mines preliminary report 170.

Malde, H. E., and Boyles, J. M., 1976, Maps of alluvial valley floors and strippable coal in forty-two 7 1/2-minute quadrangles, Big Horn, Rosebud, and Powder River Counties, Southeast Montana: U.S. Geological Survey Open-File Report 76-162, 49 p.

Mapel, W. J., and others, 1977, Summary of the geology, mineral resources, environmental geochemistry, and engineering geologic characteristics of the northern Powder River coal region, Montana: U.S. Geological Survey Open-file Report 77-291.

Marsh, A. R. W., 1978, Sulfur and nitrogen contributions to the acidity of rain: Atmospheric Environment, v. 12, p. 401-406.

Massey, Garth, 1977, Newcomers in an impacted area of Wyoming: Laramie, University of Wyoming, Department of Sociology and Center for Urban and Regional Analysis,126 p., appendixes.

______1978, Building a power plant; newcomers and social impact: prepared under a grant from the National Institute of Mental Health, Final Report, Laramie, University of Wyoming, 105 p., appendixes.

Matson, R. E., 1975, Description of seams, Montana, <u>in</u> 1975 Keystone coal industry manual: McGraw Hill, Inc., New York, p. 577-584.

Matson, R. E., and Blumer, J. W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana; Analytical data by L. A. Wegelin: Montana Bureau of Mines and Geology bulletin 91, 135 p., 34 pl.

McAllister, D. C., Ruby, M., and Vichorek, D., 1979, Draft environmental impact statement, Montana ambient air quality standards study: Montana Department of Health and Environmental Sciences, Air Quality Bureau, January 3, 1979, 277 p.

McLean, G. A., 1975, An archeological survey of the Ashland District, Custer National Forest: Missoula, University of Montana.

McQuiston, J. M., 1978, Regression analysis and summary of the impact of mining industry on Big Horn, Custer, Powder River, Rosebud, Sheridan, and Treasure Counties: Missoula, Montana, Final unpublished report submitted to NPRB EIS Task Force, 42 p.

______1979, The impact of coal development on the northern Powder River county social services: Missoula, Montana, Unpublished report submitted to the NPRB EIS Task Force.

Meadowlark Group, 1978a, Socio-economic study of the proposed Shell Oil Company Pearl mine: Report prepared for the Montana Department of State Lands, Helena, Montana, 390 p.

______1978b, Report to the Department of State Lands on the economic impact of the Big Sky mine expansion: Helena, Montana, 263 p.

Merton, R. K., 1968, Social theory and social structure, enlarged ed.: New York, New York Free Press, 702 p.

Mikol, S. A., 1977, Distribution and abundance of breeding birds on surface-mineable coal lands in the northern Great Plains: Department of Wildlife Ecology, University of Wisconsin, Madison, Progress Report, 73 p.

Missouri River Basin Commission, 1978, Report on the Yellowstone basin and adjacent coal area, Level B Study, Tongue and Powder, Montana, May 1978: p. II-22.

Montana Department of Fish and Game, 1976 (Draft), Statewide comprehensive outdoor recreation plan (SCORP); (1978, Final) v. 1, A strategic plan for the protection, perpetuation, and use of Montana's wildlife, fish and recreation resources; v. 2, Outdoor recreation inventory: Helena, Montana.

Montana Department of Highways, 1976, Montana's highway needs related to hauling energy resources and other energy induced needs: Planning and Research Bureau Report, Helena.

______1977, 1977 Montana primary highway sufficiency ratings: Planning and Research Bureau, Helena, Prepared in cooperation with the U.S. Department of Transportation and the Federal Highway Administration, 188 p.

______1978, Tentative construction program, fiscal year 1978 through 1983: Planning and Research Bureau Report, Helena, May 1, 1978.

Montana Department of Labor and Industry, 1971-78, Montana employment and labor force: Helena, Montana, monthly report, vs. 1-8.

______1974, Montana manpower, projected Montana employment by industry and selected occupations, 1970-78: Helena, Montana, Montana State Employment Service, September 1974, 56 p.

______1977, Montana employment and labor force: Helena, Montana, monthly report, v. 17, no. 7, July 1977.

______1978, Montana employment and labor force: Helena, Montana, monthly report, v. 8, no. 10, October 1978.

Montana Department of Natural Resources and Conservation (DNRC), 1974, Draft environmental impact statement on Colstrip electric generating units 3 and 4, 500-kilovolt transmission lines and associated facilities, November 1974.

______1976, Yellowstone River Basin; draft environmental impact statement for water reservation applications: Helena, Montana, v. 1, 217 p.; v. 2, 413 p.

Montana Department of Revenue, 1945-76, Report of the State Department of Revenue, various volumes during the period 1945-76.

______1977, Report of the State Department of Revenue, for the period July 1, 1974 to June 30, 1976, Helena, Montana, 130 p.

Montana Department of State Lands, 1977, Final environmental impact statement for the proposed expansion of Western Energy Company's Rosebud mine into areas A and E: v. II, Appendices, September 6, 1977, p. A-4, A-5.

Montana Power Company, 1977, Colstrip fact sheet (pamphlet).

Montana State University, Agricultural Experiment Station, 1954, Montana population changes, 1920-50.

Morgan, Thomas, 1966, History of coal mining in Montana, from the proceedings of the first Montana coal resources symposium, special publication 36 of the Montana Bureau of Mines and Geology, March 1966, 89 p.

Mountain West Research, Inc., 1975, Construction worker profile--Community report, Forsyth and Colstrip, Montana: A Study for the Old West Regional Commission, December, 1975.

Munn, R. E., 1966, Descriptive micrometerorology: New York, Academic Press, 245 p.

Murray, F. X., ed., 1978, Where we agree: report of the National Coal Policy Project, v. II.

Nalco Environmental Sciences, 1977, Short-term high volume sampling along Burlington Northern Railroad right-of-way, August 24-25, 1977: Lincoln, Nebraska, Report to Lincoln/Lancaster County, Railroad Transportation Safety District, September 21, 1977, Project No. 5501-08871, 13 p.

National Academy of Sciences, 1974, Rehabilitation potential of Western coal lands--A report to the Energy Policy Project of the Ford Foundation: Cambridge, Massachusetts, Ballinger Publishing Co., 198 p.

National Institute of Mental Health (NIMH), 1977, Mental health of rural America, 180 p.

Nichols, T. C., Jr., and Chleborad, A. F., 1977, A preliminary basis for prediction of natural slope stability, in Mapel, W. J., and others, Summary of the geology, mineral resources, environmental geochemistry, and engineering geologic characteristics of the northern Powder River coal region, Montana: U.S. Geological Survey Open-file Report 77-291.

Nimerick, K. H., and Laflin, G. P., 1977, Intransit wind erosion losses of coal and method of control: Paper presented at the SME fall meeting and exhibit, October 19-21, St. Louis, Missouri, 15 p.

Northern Cheyenne Tribe, 1976, The Northern Cheyenne air quality redesignation report and request: Prepared by the Northern Cheyenne Research Project, Richard Monteau, Coordinator, under the direction of the Northern Cheyenne Tribe, Allen Rowland, President, Northern Cheyenne Tribal Council.

Northern Great Plains Resource Program, 1974, Atmospheric aspects work group report: Discussion draft, December 1974, 428 p.

Oliver, W. W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U.S. Geological Survey Bulletin 1050, 82 p.

Oliver, J. E., 1973, Climate and Man's Environment: New York, John Wiley and Sons.

Olson, G. R., 1973, Range conditions on abandoned cropland in north-central Montana: Missoula, University of Montana, unpublished M.S. thesis.

O'Toole, J. J., Gordon, C. C., Rancitelli, L. A., Munshower, F. F., Perkins, R. W., Crecelius, E. A., and Tourangeau, P. C., 1977, Potential of energy extraction processes in the northern Great Plains for heavy metal contamination and consequent uptake and turnover in a range ecosystem model: Ames Laboratory, Iowa State University, Quarterly Report, July 1977, 15 p., tables.

Osgood, E. S., 1929, The day of the cattleman: Minneapolis, University of Minnesota Press.

Osterwald, F. W., and others, 1977, Engineering geologic characteristics, in Mapel, W. J., and others, Summary of the geology, mineral resources, environmental geochemistry, and engineering geologic characteristics of the northern Powder River coal region, Montana: U.S. Geological Survey Open-file Report 77-291.

Paulson, L. E., Cooley, S. A., Wegert, C., and Ellman, R. C., 1976, Experiences in transportation of dried low-rank western coals: Society of Mining Engineers, AIME, Transactions, v. 260, p. 300-305.

PEDCo-Environmental, Inc., 1977, Southeastern Montana coal resource AQMA analysis: Prepared for the U.S. Environmental Protection Agency, Region 8, under Contract no. 68-02-1375, Denver, Colorado, 48 p.

______1978, Survey of fugitive dust from coal mines: Prepared for the U.S. Environmental Protection Agency, EPA 908.178003, 115 p.

Perera, F. P., and Karim Ahmed, A., 1978, Respirable particles--impact of airborne fine particulates on health and the environment: Report of the Natural Resources Defense Council, 252 p.

Payne, G. F., 1973, Vegetative rangeland types in Montana: Bozeman, Montana Agricultural Experiment Station, Bulletin 671, 16 p.

Poon, L. C. L., 1978, Railway externalities and residential property prices: Land Economics, v. 54, p. 218-227.

Proctor, J., and Woodwell, S. R., 1975, The ecology of serpentine soils: Advances in Ecological Research, v. 9, p. 255-366.

Pueschel, R. F. and VanValin, C. C., 1976, Cloud nuclei formation in the plume of a coal-fired power plant: American Geophysical Union Transactions, v. 57, p. 925.

Quimby, D. C., 1966, A review of literature relating to the effects and possible effects of sagebrush control on certain game species in Montana: 46th Annual Conference of Western Association State Game & Fish Commissioners, 13 p.

Rahn, P. H., 1976, Potential of coal strip-mine spoils as aquifers in the Powder River Basin: Billings, Montana, Report prepared for the Old West Regional Commission, Project 10470025, 108 p.

Rao, D. H., 1971, A study of the air pollution problem due to coal unloading in Varanosi, India: Proceedings, Second International Clean Air Congress, Washington, D.C., 1970, H. M. England and W. T. Beery, eds.: New York, New York Academic Press, 354 p.

Renne, D. S., and Elliott, D. L., 1976, Regional air quality assessment for probable near-term coal-related energy development in the northwest: Richland, Washington, Battelle Pacific Northwest Laboratories, October 1976, 38 p.

Robinson, R. J., 1977, Associate Fiscal Analyst of the Coal impact and Coal board grants: State of Montana Office of the Legislative Fiscal Analyst, unpublished report to the Legislative Finance Committee, 29 p.

Sandoval, F. M., Bond, J. J., Power, J. F., and Willis, W. O., 1973, Lignite mine spoils in the Northern Great Plains--Characteristics and potential for reclamation, in M. K. Wali, ed., Some environmental aspects of strip mining in North Dakota: North Dakota Geological Survey Educational Series 5, p. 1-24.

Sandoval, F. M., and Gould, W. L., 1978, Improvement of saline- and sodium-affected disturbed lands, in Schaller, F. W., and Sutton, Paul, eds., Reclamation of drastically disturbed lands: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin, p. 485-502.

Sandoval, F. M., Power, J. F., and Ries, R. E., 1978, Sodium migration upward on reclaimed sodic mine spoils: Bozeman, Montana, presented in Western Soil Science Society meeting, July 17-20, 1978.

Schafer, W. M., Nielson, G. A., Dollhopf, G. A., and Temple, K., 1978, Soil genesis hydrological properties, root characteristics, and microbial activity of 1 to 50 year-old stripmine spoils: Bozeman, Montana, Montana Agricultural Experiment Station, Montana State University, 209 p.

Sheridan, R. P., and Rosenstreter, R., 1973, The effect of hydrogen ion concentrations in simulated rain on the moss Tortula ruralis (Hedw.) Sm.: The Bryologist, v. 76, no. 1, p. 168-173.

Sherman, G. D., Schultz, F., and Alway, F. J., 1962, Dolomitization in soils of the Red River valley, Minnesota: Soil Science, v. 94, p. 304-313.

Small, K. A., 1975, Air pollution and property values--Further comment: Review of Economics and Statistics, v. 57, p. 105-107.

Super, A. B., Heimbach, J. A., and McPartland, J. T., 1973, Air pollution potential determination program for Colstrip, Montana: Bozeman, Montana, Department of Earth Sciences, Montana State University, April 1973, 108 p.

Temple, G. S., 1978, A dynamic economic systems community impact model applied to coal development in the Northern Great Plains: Bozeman, Montana, Department of Agricultural Economics and Economics, Montana State University, in cooperation with the Economic, Statistics, and Cooperative Service, U.S. Department of Agriculture and Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C., prepared for partial fulfillment of EPA contract EPA-IAG-D8-E766, 142 p.

Thompson, L. S., 1977, The taxation and revenue system of State and local government in Wyoming as of 1976: Bozeman, Montana State University, Department of Agricultural Economics and Economics, in cooperation with Economic Research Service, U.S. Dept. of Agriculture and Office of Research and Development, U.S. Environmental Protection Agency, prepared for partial fulfillment of EPA contract EPA-IAG-D6-E766, 58 p.

Thompson, James, and others, 1978, Report on the impact of strip mining on Sheridan County, Wyoming: Laramie, Wyoming, Center for Urban and Regional analysis, University of Wyoming, unpublished report, 153 p.

Thornthwaite, C. W., 1931, The climates of North America according to a new classification: The Geographical Review, v. 21, p. 633-654.

Toole, K. R., 1976, The rape of the Great Plains--Northwest America, cattle and coal: Boston, Massachusetts, Little, Brown and Company, 271 p.

______1977, Twentieth century Montana, a state of extremes: Norman, University of Oklahoma Press.

Unsworth, M. H., Biscoe, P. V., and Pinckney, H. R., 1972, Stomatal response to sulfur dioxide: Nature, v. 239, p. 458-459.

U.S. Bureau of Reclamation, 1971, North central power study: 2 v.

U.S. Community Services Administration, 1975, Special poverty statistics for CSA (OEO) from the 1970 census of 1969 incomes: unpublished, Washington, D.C.

U.S. Department of Agriculture, 1971, Soil survey--Powder River area, Montana: 99 p. and maps.

______1975, Soil taxomony--A basic system of soil classification for making and interpreting soil surveys: Agricultural Handbook 436, 754 p.

______1978, Soil survey of Big Horn County area, Montana: 233 p. and maps.

U.S. Department of Commerce, 1971, Climatological summary, 1941-70, Station Colstrip, Montana: Climatography of the United States, No. 20-24.

______1972, Employment by type and broad industrial sources, 1970, full and part-time wage and salary employment plus number of proprietors: Bureau of Economic Analysis, Regional Economic Information System, unpublished data from table 25.00, Washington, D.C.

______1973, Precipitation-frequency atlas of the Western United States: National Oceanic and Atmospheric Administration (NOAA), Atlas 2, v. 1, Montana.

______1974, 1972 Census of retail trade, area statistics: Bureau of Census, U.S. Government Printing Office, Washington, D.C., Montana RC72-A-27, 43 p.

______1975, Regional employment by industry, 1940-70: Bureau of Economic Analysis, 542 p.

______1977, Employment by type and broad industrial sources, 1971-75, full and part-time wage and salary employment plus number of proprietors: Bureau of Economic Analysis, Regional Economic Information System, unpublished data from table 25.00, Washington, D.C.

U.S. Department of Housing and Urban Development (HUD), 1976, Rapid growth from energy projects, 59 p.

U.S. Department of the Interior, 1970-78, Report of labor force: Bureau of Indian Affairs, Planning and support group annual report, form 5-2119, unpublished.

U.S. Department of the Interior, Bureau of Mines, 1932, Analysis of Montana coals: U.S. Bureau of Mines Technical Paper 529, 129 p.

U.S. Department of the Interior, Fish and Wildlife Service (FWS), Division of animal damage control records, Billings, Montana.

U.S. Department of the Interior, 1975, Resource and potential reclamation evaluation, Otter Creek study site: EMRIA Report No. 1, 200 p.

______1976a, Water resources data for Montana, water year 1976: U.S. Geological Survey Water-data Report MT-76-1, prepared in cooperation with the State of Montana and other agencies, 766 p.

______1976b, Water resources data for Wyoming, water year 1976; vol. 1, Missouri River Basin: U.S. Geological Survey Water-data Report WY-76-1, prepared in cooperation with the State of Wyoming and other agencies, 631 p.

______1977a, Resource and potential reclamation evaluation Bear Creek area--West Moorhead coalfield: EMRIA Report No. 8, 148 p.

______1977b, Water resources data for Montana water year 1977: U.S. Geological Survey Water-data Report MT-77-1, prepared in cooperation with the State of Montana and other agencies, 751 p.

______1977c, Water resources data for Wyoming, water year 1977; volume 1, Missouri River Basin: U.S. Geological Survey Water-data Report WY-77-2, prepared in cooperation with the State of Wyoming and other agencies, 615 p.

U.S. Energy Research and Development Administration (ERDA), 1977, Synthetic liquid fuels development: Assessment of critical factors, v. 3, 230 p.

U.S. EPA, 1973, National Air Monitoring Program, Air quality and emission trends, annual report: v. 2., August 1973, EPA 450/1-73-001.

______1976a, Compilation of air pollutant emission factors, 2d ed.: AP-42, Part B, February 1976.

______1976b, Levels of trace elements in the ambient air at selected locations in the Northern Great Plains: Region VIII, EPA Contract No. 68-02-1383, Task 7, September 1976, 35 p.

______1977, Growth management for small communities, Sheridan, Wyoming: Boulder, Colorado Action Handbook, Prepared for the U.S. Environmental Protection Agency by Briscoe-Maphis, Inc., 86 p.

University of Wyoming, 1977, Weather modification potential of coal-fired power plants: Prepared for the Old West Regional Commission, 138 p.

URS, 1976, Coal train assessments, Final report, December 15, 1976, p. V-16.

VanValin, C. C., and Pueschel, R. F., 1977, Atmospheric aerosol observations at Colstrip, Montana: Boulder, Colorado, Atmospheric Physics and Chemistry Laboratory, NOAA, ERL, 4 p.

VanVoast, W. A., and Hedges, R. B., 1975, Hydrologic aspects of existing proposed strip coal mines near Decker, southeastern Montana: Montana Bureau of Mines and Geology, Bulletin 97, 31 p.

Webb, W. P., 1931, The Great Plains: New York, Grosset and Dunlap, 525 p.

Weist, Tom, 1977, A history of the Cheyenne people: Billings, Montana Council for Indian Education.

Western Interpretive Services, Inc., 1977, Historical resources and evaluations for the Powder River study area: Sheridan, Wyoming, prepared for Anthro Research.

White, K. L., Hill, A. C., and Bennett, J. H., 1974, Synergistic inhibition of apparent photosynthesis rate of alfalfa by combinations of sulfur dioxide and nitrogen dioxide: Environmental Science and Technology, v. 8, p. 574-576.

Whittaker, R. H., Bormann, F. H., Likens, G. E., and Siccama, T. G., 1974, The Hubbard Brook ecosystem study; forest biomass and production: Ecological Monograph, v. 44, p. 233-252.

Williams, Michael, 1978, Testimony on Colstrip units 3 and 4: Billings, Montana, U.S. EPA public hearing, February 12, 1978.

Woessner, W. W., 1979, Input-output modelling of potential impacts of coal strip mining: Northern Cheyenne Reservation, Montana, Geological Society of America, Abstracts with Program, v. 11, no. 6.

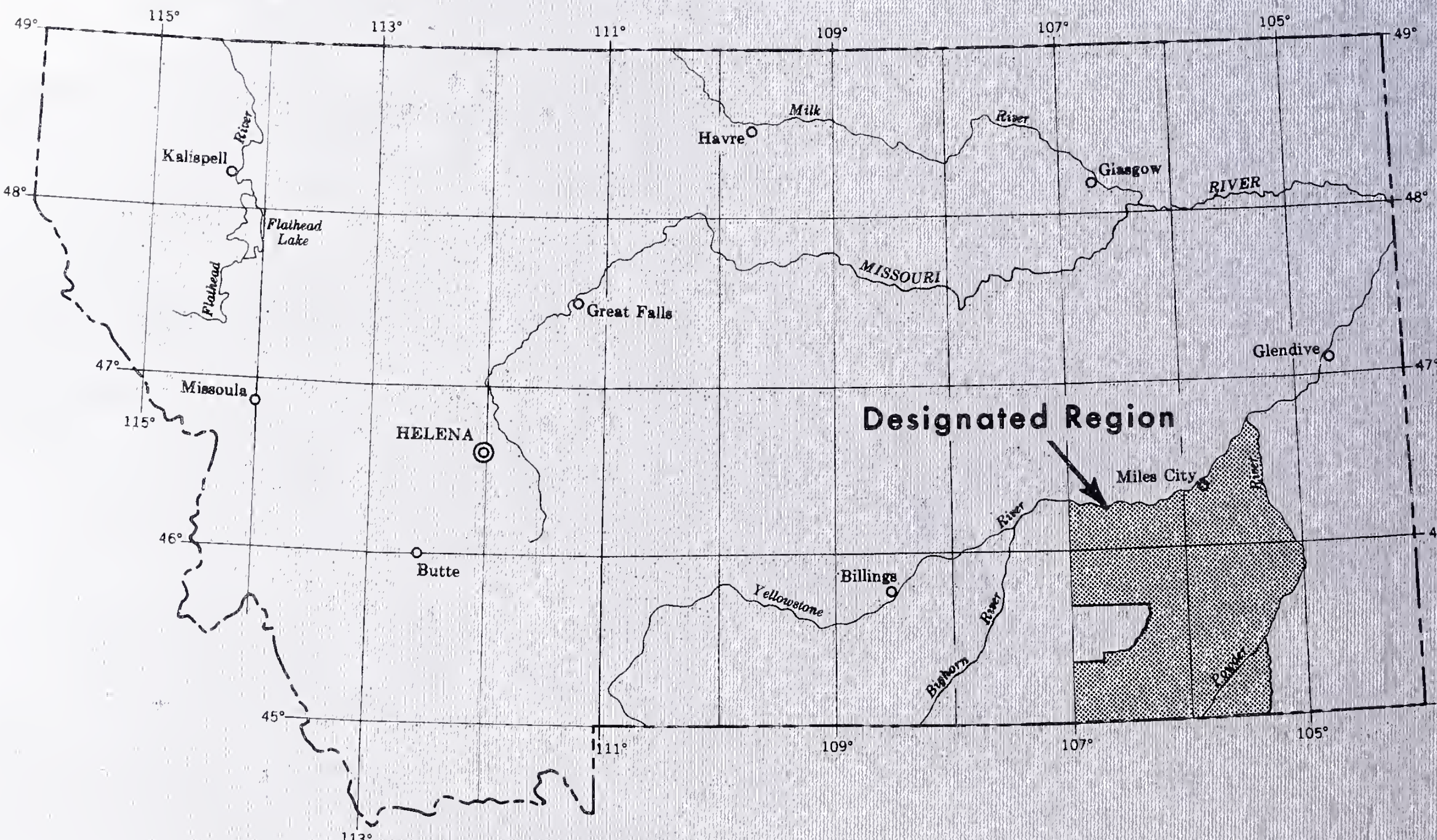
Wong, C. S., 1978, Atmospheric input of carbon dioxide from burning wood: Science, v. 200, p. 197-200.

Woods, M. J., 1978, Geochemistry of the Fort Union Formation with implications for quality of waters in mined lands: Report submitted to the NPRB-EIS State team, 56 p.

Wyoming State Highway Department, Planning Division, 1977, Wyoming Traffic.

Yannone, Vince, 1973, The black-footed ferret in Montana, in Linder, R. L., and Hillman, C. N., eds., Proceedings of the black-footed ferret and prairie dog workshop: South Dakota State University, Rapid City, September 4-6, 1973.

Zeimens, G. M., and Walker, D. N., eds., 1977, Archeology of the eastern Powder River Basin, Wyoming: Report prepared for the U.S. Bureau of Land Management, under contract No. YA-512-RFP6-104.



INDEX MAP OF MONTANA

50 0 50 100 Miles

1879 · CENTENNIAL · 1979
U.S. GEOLOGICAL SURVEY